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APPENDIX A

SFBFS – B Model Detailed Evaluation

APPENDIX A
SFBFS-B MODEL DETAILED EVALUATION
North Hollywood Operable Unit
Second Interim Remedy
Groundwater Remediation Design

1.0 INTRODUCTION

Evaluations of alternatives proposed for the remediation of groundwater contamination in the North Hollywood Operable Unit (NHOU) conducted for USEPA by CH2M Hill were supported by the use of a numerical groundwater flow model. The model was originally constructed by James Montgomery Consulting Engineers in 1992. CH2M Hill provided an updated version of that model for the US Environmental Protection Agency (USEPA) in 1994. The newer version of the model was named the San Fernando Basin feasibility study (SFBFS) model, and was again updated in 1998 (the SFBFS-A model) and in 2001 (SFBFS-B model). Updates incorporated additional basin-wide data, shifting to a MODFLOW-SURFACT model code to overcome stability problems resulting from transient simulations where nodes were successively dewatered and rewetted, and calibration relative to a target water level database that extended through 1999. The model was again revised to support the 2009 Focused Feasibility Study (FFS) and included horizontal refinement of the model grid in the vicinity of the North Hollywood well fields (to as small as 50-by-50-foot grid cells), and recalibration to water level data (with added monitoring locations in the North Hollywood area) through 2006. The vertical discretization has remained at four layers. Appendix B to the 2009 FFS stated that improved recalibration to the expanded water level data set required increasing the horizontal and vertical hydraulic conductivities throughout the model by 50 percent, altering the conductance of the groundwater model river package near the Los Angeles (LA) River Narrows, and eliminating a small zone of low hydraulic conductivity (K) nodes at the Narrows that likely represented a fault zone. The FFS utilized the model to aid in the evaluation of interim groundwater alternatives that would result in adequate capture of contaminant plumes and thereby prevent potential migration of these contaminants to nearby water supply well fields, even under future conditions of dry spells and increased water supply demand.

In response to the USEPA Record of Decision (ROD) requirements, Lockheed Martin and Honeywell International (Honeywell) have assumed responsibility for the design of a modified groundwater extraction and treatment system to achieve Specific ROD goals, including use of captured and treated water to help conserve the San Fernando Valley (SFV) water supply.

Questions have been raised as to the ability of the existing groundwater model to adequately depict groundwater flow in the North Hollywood area with respect to simulations of proposed revisions to the NHOU extraction system. The main concern is for the simple representation of the vertical thickness of the overburden aquifer (four layers) to allow an accurate depiction of vertical flow in the aquifer. Existing data will be re-examined to see if the model can be improved to depict groundwater flow under anticipated future conditions, including the potential installation addition of or modification to existing extraction wells. As part of this re-evaluation of the model, this review is intended to better understand the capabilities, operation, and limitations of the existing SFBFS model. It is also intended to provide a more comprehensive description of the elements of the model and explain how the model works in preparation of any revisions that might be made to it. It should be noted here that any significant revisions to the model will depend greatly on the examination of all data in developing a refinement of the hydrogeologic conceptual model and the ability of the examined data to support changes to the model.

This appendix includes a review of model documentation, including grid construction, boundary condition representation, aquifer parameter distribution, calibration targets, calibration results, and results of four FFS simulations included in the package for review.

2.0 MODEL FILES AND DOCUMENTATION FOR REVIEW

This review mainly covers examination of NHOU files posted to the CH2M Hill public FTP site (ftp://ftp.ch2M.com/public_SFV/), the CH2M Hill 1994 model documentation, and the 2009 Focused Feasibility Study (FFS) with Appendix B model discussion (USEPA, 2009a). The downloaded files included:

- Modeling platform Groundwater Vistas file (.GWV) for the calibrated FFS model, including output cell-by-cell (.CBB) and head (.HDS) binary files (indicated as Run 523ECR).
- Groundwater Vistas file with output .CBB and .HDS files for the No Further Action (NFA) under dry and average conditions (indicated as Runs 554 and 555, respectively).
- Groundwater Vistas file with output .CBB and .HDS files for the alternative considering three new deep extraction wells positioned with the intent to protect the southern extent of the Rinaldi-Toluca well field with deepened or otherwise modified NHE-1 through NHE-8 wells under dry and average conditions (indicated as Runs 552 and 553, respectively).

The SFV model was also downloaded from a separate folder, but appears to be essentially the same as the FFS model and will not be discussed further. The Glendale model (which covers the same area as the FFS model) was also available for download, but will be discussed only briefly later in this review. However, information imbedded in the Glendale model files was useful in evaluating the NHOU model.

Other relevant documents include: the 1992 Remedial Investigation (RI); 2010 Draft Groundwater Characterization Report (MWH, 2011); the Interim Action ROD (USEPA, 2009b); and the Annual Report of the ULARA Watermaster Groundwater Pumping and Spreading Plan (ULARA Watermaster, 2011).

3.0 MODELING SOFTWARE

The software programs in current use to develop and run the numerical groundwater flow model include Groundwater Vistas (GWV), MODFLOW-SURFACT, and MODPATH.

3.1 GROUNDWATER VISTAS

Groundwater Vistas (GWV) is a groundwater modeling platform into which all relevant hydrogeologic information is entered; GWV version 6 was used to develop/review models discussed herein. When the data is fully entered, GWV produces an input data set for the particular model the user chooses, in this case, MODFLOW-SURFACT. MODFLOW-SURFACT is a separate entity from the models provided with GWV (must be purchased separately since it is not public domain software), but will run under GWV when the path to MODFLOW-SURFACT is identified. MODPATH is a USGS code that computes flow velocity vectors and groundwater flow pathlines from MODFLOW output head matrices.

Observed water levels are one type of data which can be entered which GWV will use to generate residuals (observed water level difference from model computed heads at the target locations) for statistical goodness-of-fit comparisons during calibration. Typical statistical measures that the modeler will look to minimize are the residual mean, absolute mean, standard deviation, and normalized standard deviation. These measures will be one guide in adjusting model input parameters to obtain a satisfactory representation of the aquifer system. GWV can also contour output head data and export model features and other output in a variety of formats.

3.2 MODFLOW

MODFLOW is an evolving numerical groundwater flow modeling code developed by the USGS. It has undergone several modifications within USGS to enhance its capabilities since its first major release in 1988. These model codes reside in the public domain. In addition, others have also sought to enhance MODFLOW with specialized capabilities. One such enhancement is MODFLOW-SURFACT by HydroGeologic. MODFLOW-SURFCACT was developed to address the problem of drying model cells, and, in the case of transient analyses, include rewetting of dry cells. The USGS had developed a rewetting package, but this was often unable to produce satisfactory results and more often led to severe instability in the model. MODFLOW-SURFACT overcame these difficulties more successfully. A second problem that MODFLOW-SURFACT addressed was that of well screens that spanned more than one aquifer. In the traditional MODFLOW approach, well rates were a priori assigned to the various levels based on respective transmissivity of the layer and without regard for the physical ability of the well to actually produce or maintain this rate, especially for time-dependent unconfined aquifer conditions. MODFLOW-SURFACT overcame these by internally computing rates to be assigned to each layer and by keeping track of the water level in the model layer relative to pump or bottom well screen elevation. The earlier SFBFS model used the conventional MODFLOW code, but due to the dewatering of portions of model layer one, the switch was made to MODFLOW-SURFACT in 2001. The more recent runs of the SFV model (for Glendale) have used MODFLOW-SURFACT version 3 with the PCG5 solver, which significantly reduces the run times of simulations.

3.3 MODPATH

MODPATH is an adjunct USGS code that takes output head files generated by MODFLOW and the specified effective porosity to compute flow vectors and flow lines through the model. The user inputs starting positions for “particles” that will follow flow lines and trace them out for further display. The particles may be tracked in either a forward or reverse mode to see where they might go, or where the water may have originated from. In both forward and reverse mode, MODPATH is a frequently used program to aid in the determination and depiction of capture zones established by pumping centers. Options in MODPATH also include that the particles could pass through weak sinks (nodes in which some flow exits), are captured by a specified boundary condition, or are captured if the sink captures a specified percentage of the flow entering the model cell. Time of travel (groundwater flow rates) from point of interest to source or probable final destination may also be a MODPATH output. Typically, a particle will travel to, and exit at, an internal or perimeter boundary condition, but requested output may also specify a time limit on time of travel for the pathlines. GWV is capable of displaying the particle tracks on screen, and outputting them in a variety of formats.

In the SFBFS-B model, particles have placed (seeded) at the interpreted extents of VOC or chromium target capture zones (but included both 5 and 50 micrograms per liter envelopes) in the NHOU plume area. While some contaminants have been detected in Depth Region 2 above criteria, the majority of the contaminant mass appears to be confined to the relatively shallow aquifer represented by Depth Region 1. A total of 539 particles were seeded in the SFBFS-B model. Tracked forward, they either exit at extraction wells or at production wells depending on pumping and aquifer conditions. Those particles that pass by these wells could eventually exit the model at a perimeter boundary condition. Particles trace out pathlines that groundwater would be expected to follow. Contaminants would tend to follow these paths, but would be subject to other mechanisms that may limit their travel distance before becoming non-detect, e.g., degradation or sorption.

4.0 MODEL STRUCTURE

This section presents the structure of the model, including domain, grid design, model layers, and boundary conditions (including diffuse recharge).

4.1 MODEL DOMAIN

The horizontal model domain includes the major portion of the San Fernando Basin (SFB) which covers an approximate 170 square miles. The model domain for model layer 1 is shown on Figures A-1a and A-1b. The basin narrows with depth and so does the active model domain (see Figures A-2, A-3, and A-4). The SFB receives inflow from several other adjacent smaller basins. These adjacent basins are not part of the model domain, but the average estimated influx from each of these is included in the model and remained constant throughout all model runs examined. These include the sub-basins of Sylmar (subdivided into Sylmar and Pacoima), Verdugo, and Eagle Rock.

Vertically, the model domain includes all alluvial overburden above the basement rock. The thickness of the overburden ranges from near zero at rock outcrops and the surrounding mountain areas, to over 1,200 feet in the deepest portions. Model layer thicknesses range widely corresponding to a division of the total aquifer thickness into four depth regions based on inferred similarity of hydrogeologic properties described in the RI (Montgomery, 1992). Model layer one, the shallow aquifer, or Depth Region 1, varies from being very thin at the bordering mountains to being encountered up to 200 to 280 feet below ground surface (bgs) in the more central portions of the model domain. The water table is typically deep, and depth may vary widely at specific locations due to excessive pumping and/or limited recharge within the SFB. In places, Depth Region 1 may go dry, and infiltrating recharge may take a relatively long time to percolate from ground surface to the water table (CH2M Hill, 1994). Model layer two, Depth Region 2, ranges from about 280 to 420 feet bgs. Model layer 3, Depth Region 3, ranges from about 420 to 660 feet bgs. Finally, model layer 4, Depth Region 4, ranges from about 660 feet bgs and deeper (MWH, 2010).

4.2 MODEL GRID

Earlier versions of the model were discretized (overlain with a rectangular grid) with row or column dimensions of from 1,000 to 3,000 feet (Montgomery, 1992). The grid type was, and remains, variable, with smaller grid block sizes assigned to areas of particular interest, and larger block sizes in areas of little key interest, usually toward the periphery of the model active area. In the latest EPA version, the model grid dimension has been refined to about 50-foot blocks near the NHOU. This refinement is obscured by the dense grid lines in this area when viewing the entire model domain (Figure A-5), but Figure A-6 shows the grid relative to the areas of the NH extraction wells more clearly. The finer model discretization has increased the number of rows in the model from 64 to 243, and the number of columns from 86 to 272 from the original RI model. The number of active nodes in each model layer decreases with depth due to the geometry of the basin, so that the current model has a total of 197,135 active nodes.

Even with refined block size on the order of 50 feet, the model response to pumping stress may not be adequate for accurate particle tracking simulations in the vicinity of extraction wells. The groundwater flow model produces a block-averaged estimate of the head and thus gradients into a producing well, as well as drawdowns, may be underestimated. Examination of this potential effect on model conclusions should be examined relative to capture and ability of the well to sustain necessary groundwater flow rates (especially in Depth Region 1).

4.3 Model Layers

As indicated above, the layering in the model reflects the conceptualization of the SFB aquifer into four major depth zones. This approach is discussed in the earlier model documentation (Montgomery, 1992; CH2M Hill, 1994) which notes that these depth zones consist of discontinuous fine- and coarse-grained zones, but are primarily coarse-grained and relatively highly permeable, especially in the eastern side of the SFB. The depth zones are each considered to contain similar properties. This vertical discretization was based on RI data and the Report of Referee (as referenced by CH2M Hill, 1994). This vertical definition has been maintained in the current SFBFS-B model. While other interpretations have been proposed and continue to evolve, we will maintain the correlation of the SFBFS model as each layer corresponding to a depth region when discussing this current version of the model.

More recent data and re-evaluation of available data has generally supported this vertical definition, but also suggests that additional detail could be built into the model that could increase model accuracy (MWH, 2010). Additional vertical discretization of the model will likely be required to support design of the selected second interim remedial measure, possibly in response to a changing conceptualization of the stratigraphy, but definitely in simulations exploring the appropriate screened intervals for future wells relative to the vertical distribution of contaminants in the aquifer.

4.4 Model Coordinate System

GWV, the modeling platform, offers the modeler two choices of coordinate system for the model. The first is model coordinates in which the origin of the grid (lower left hand corner) is assigned as (0,0) while the second used in the SFBFS-B model appears to be NAD27, zone 7, which is a zone that includes LA County. In this system, the model origin is (4,091,000; 4,143,000). The model grid is not rotated with respect to north. Newer survey in the NHOU (e.g., the 2009 wells installed by Honeywell) utilizes the North American Datum of 1983, (NAD83 CA State Plane zone 5), and newer surveyed well locations are in this system. It may be beneficial at some point to convert the model actual coordinate system to NAD83; however, for consistency, the older coordinate system will be referenced here.

4.5 BOUNDARY CONDITIONS

There are several types of boundary conditions in the model. These are represented in the model using the MODFLOW no-flow, constant head, general head boundary (GHB), river, and well packages (see Figure A-1). The use of each package is detailed in the following subsections.

4.5.1 No-Flow boundaries

No-flow nodes surround the active portion of the model and correspond to the defined extent of the watershed or basin. The active portion of the model decreases with depth in conformance with the geometry of the San Fernando Valley basin.

4.5.2 Constant head

There is one sole constant head (CH) node in the model. This is located in model layer 1 at the junction of the Eagle Rock sub-basin discharge to the SFV aquifer near the City of Burbank. The CH value is set at a steady state head of 450 ft for the FFS Calibrated Model run, and contributes about 120 gpm (end of the 25-year calibration run) into the model. An analytical well representing the sub-basin influx to the SFB is also located in this node, and contributes about 15.5 gallons per minute (gpm) into the model, but only for the first 16 years when it shuts off. Curiously, for the simulations of alternatives, the constant head is set at 302 feet elevation, and removes about 22 gpm from the SFB; the analytical well representing influx from the Eagle Rock sub-basin is set to zero for these runs. The low flow rates involved and the distance from the NHOU would indicate that the CH has no significant effect on conditions in the vicinity of the NHOU.

4.5.3 GENERAL HEAD BOUNDARIES

There are five GHB nodes in the model located at the extreme southeastern extent of the model. These represent the groundwater outflow from the model through the Los Angeles River Narrows. Use of a GHB allows the model heads to flex in response to internal stresses to the model whereas a constant head would maintain the node at the specified head and could represent an infinite capacity source or sink. The GHB offers a more realistic response in many cases than the constant head. However, the conductance term (representing the local gradient and transmissivity of the node), if set too high, may make a node behave as a constant head. This boundary condition, while variable during the transient runs, represents a relatively small fraction of the total water balance, about 300 gpm or less than one percent, and has no significant effect in the model in the NHOU vicinity.

4.5.4 River package

The Los Angeles River runs along the southern perimeter of the active model layer 1 domain (see Figure A-1a). The MODFLOW river package allows the river to act as either a gaining sink or losing source to groundwater depending on the relative elevations of the groundwater in the river package node and the specified stage (elevation) of the water in the river. The ease of interaction of the groundwater and surface water is moderated by a conductance term which is a lumped parameter including the vertical hydraulic conductivity of any sediments in the river bottom, the thickness of the sediments, and the area of the river within the river node. The conductance is rarely well known, especially given the length of the river or stream and available data, and usually becomes a calibration parameter if the model is sensitive to conductance. The cleaner the river bottom is (i.e., little sediment), the better the potential interaction and the greater the conductance. The Los Angeles River is lined in some sections and is represented here with low conductance, while in other reaches, the connection is good and the conductance high. If the groundwater elevation in a river node drops below the bottom of the river, the river seepage rate drops to a free-draining rate constant. In the model, the river is taken as one foot deep over much of its length. Only in two relatively short stretches is it assigned a depth of about 11 feet, one of these being at the Headwaters. Use of the river package assumes that the river does not become dry at any river node location. While regions of gaining and losing vary through the model domain, the river boundary condition has an effect on the computed water table in its vicinity. The net (gain-loss) contribution to the overall water balance is relatively small over the entire model domain, but is important locally in establishing groundwater heads.

4.5.5 Well package

The well package is used in the SFB model for three distinct purposes. First, the influx to the SFB from adjacent sub-basins is introduced via the well package operating as injection wells in model layer 1. These locations are far enough away from the NHOU area that introduction as a point source (but spread out through the volume of the model node) is not likely to result in differences than if it was introduced via areally distributed recharge. The rate of influx for the significant contributing sub-basins is maintained constant for all of the model runs examined, and represents a best estimate of average sub-basin influx (data obtained from the Upper Los Angeles River Area [ULARA] Watermaster).

Second, the well package is used to simulate injection wells to represent influx into the model domain through the several spreading basins in the SFB. Several wells are used for each spreading basin and the total influx assigned is evenly divided among the several wells. Since this influx represents both natural runoff and imported water, it varies throughout time, and can be a relatively large or small component of the water balance. In times of low spreading basin input, the water table can drop significantly. While natural percolation of recharge, even from active spreading basins, may take quite a while to percolate down through the unsaturated zone to the water table, the water as introduced to the model through the well package into model layer 1 is instantaneous. Thus some error is introduced as the simulated recharge rate (from spreading basins or through infiltration over the area of the model) does not include a time lag. The approach in the FFS modeling is that the average natural diffuse recharge is relatively constant, and significant variation is produced mainly by the spreading basins. Use of the recharge package might be intuitively more consistent and equally effective in introducing this spreading basin water into the model.

Third, the well package is used to represent the extraction wells and the water supply production wells. In many cases, the wells may be screened (more accurately described as intervals of well perforations) over more than one aquifer unit (or model layer). In this case, the withdrawal rate must be properly apportioned over the segments in each model layer. In other cases, in times of over pumping, the water level may drop below the intake of the well or the elevation of the well pump. MODFLOW, particularly MODFLOW-SURFACT, is equipped to deal with this using the fractured well (FWL) package, and the software apportions the rates properly to the various segments or drops the rate to zero if the water table drops below the intake. When the water table rises again, the well pumping rates will be restored. As specified in the SFBFS model, the bottom of the well screen is used as the cutoff level.

Use of the bottom of the well screen as a cut-off may overestimate the ability of the well to produce the target flow rates, particularly for wells screened in Depth Region 1 where the saturated thickness of the screen may become relatively small and drawdowns large relative to the screened aquifer thickness.

Review of data for screened interval elevations for existing extraction or production wells indicate that many of the entries in the model do not agree with data in the EPA database. While not all well construction data (ground surface or reference elevation) were available for calculating screen interval elevations, many of the pumping wells in the FFS simulations had different screened intervals entered into the model than contained in the EPA database. Attachment 1 summarizes indicated screened intervals for the analytical well package wells as contained in the model relative to data for perforated intervals from the USEPA database. Not all differences are expected to result in significant differences in the model results, as some are small and many upper top of screen elevations may already be above the water table, or lower screen intervals deep enough to not come into play with declining water levels. A further examination of these data is in order (see also Section 6.3.4). When anticipated additional layers are included in the model, it will be necessary to modify the input analytical well package to properly assign the layers corresponding to the top and bottom of active screen lengths (some wells are equipped with packers, such as the Burbank extraction wells, so that the active portion of the perforated length of screen is less than the total).

4.6 RECHARGE

Recharge represents the amount of water infiltrating into the subsurface that actually reaches the water table. Over large model domains an average value may be assigned, although high recharge (e.g., an infiltration basin) or low recharge (e.g., paved areas or large buildings) may locally affect water table response (i.e., mounding). Mean annual precipitation ranges from about 14 inches at the western end of the SFV to 33 inches near the higher elevations of the watershed in the San Gabriel Mountains in the easterly region of the ULARA (ULARA Watermaster, 2010). The 2010 Watermaster annual report cites a 100-year mean weighted average for the Valley floor stations of 16.48 inches per year, and of 21.76 inches per year for the Hill and Mountain stations. In the SFBFS model, recharge is assigned variably across the model domain, but kept constant through all runs examined, i.e., during both average and dry conditions. In dry conditions, the drop in water input to the model is achieved by reductions in the influx at spreading ground (represented by the well package) and compensating increased pumping during dryer times. Natural recharge across the model accounts for about 52 percent of water into the model under average estimated future conditions (final year of Run 553 simulation). As with many southern California watershed areas, the average annual recharge is relatively low; hence the need and effort to conserve, recycle, and import water to maintain the SFB as an active and sufficient reservoir for Los Angeles and adjacent communities in the SFB.

While natural recharge to the water table can be considerably delayed where the water table is very deep, the groundwater flow model cannot provide for this delay which will be variable as is the actual amount of precipitation that infiltrates and reaches the water table. The same is true for the spreading basins, although here the soil may be more fully saturated beneath the basins and the delay less. Hence, the approach taken in the existing model is reasonable, but will introduce some error in the computed water levels relative to the actual events. Varying the recharge may be necessary to achieve a greater measure of statistical fit, but for reasons noted here may be difficult to achieve basin-wide.

4.7 OTHER BOUNDARIES

In the conceptual model description, CH2M Hill indicated the presence of fault zones within the SFB and also some areas where there appeared to be discontinuities in the interpreted water level contours. A major fault line is the Verdugo Fault, and there are several other smaller ones. In the original (1994) model documentation, it is indicated that effects of fault zones would be simulated by low permeability nodes. The RI indicated that some of these faults may have a bearing on groundwater flow in the SFB. In addition, earlier Watermaster annual reports show distinct breaks in water level contours across the inferred extents of some faults. However, it appears that the only faults represented in the SFBFS model were in the LA River Narrows, and that the much more extensive Verdugo Fault was not included. Such a fault zone would be more appropriately represented using the horizontal flow barrier (HFB) package in MODFLOW. It is likely worth considering reintroducing the fault zones via the HFB package in any model revision, but it may be that these are far enough away from the extent of influence of present or proposed NHOU wells that their influence is negligible relative to the determination of resultant capture zones.

5.0 MODEL HYDROGEOLOGIC INPUT PARAMETERS

This section presents a discussion of the model hydrogeologic parameters such as hydraulic conductivity, storativity, specific yield, porosity, and initial head distribution.

5.1 HYDRAULIC CONDUCTIVITY

The model hydraulic conductivity (K) distribution has been assigned in the model using a zonation approach. In GWV, the modeler sets up a database of K zones. This entails assigning a zone number (with associated horizontal and vertical K) to specified areas in each layer. This allows adjustment of model K values by simply changing the value associated with a zone in the database.

While developing a model usually incorporates the principal of parsimony (using the minimum detail to establish a reasonable representation of the aquifer system), additional zones may be established, or areas covered by specific zones to be redistributed, as needed to improve calibration provided sufficient data warrant their inclusion. In the SFBFS model K value database, 82 K zones have been defined (ranging from nearly impermeable to 454 feet per day (ft/d), and it appears that nearly all of these zones were assigned to areas in the model. Many of these Ks differ only slightly, and some are identical. This degree of refinement seems excessive, but may be a function of specification of similar properties in different layers as different zones to aid in calibration, and to create buffer zones where large shifts in Ks for adjacent areas may exist. The zonation approach to assigning hydraulic conductivity in the model is illustrated for Model Layer 1 on Figure A-7. This approach may lend to model stability as the model, while using MODFLOW-SURFACT to overcome some node dewatering and wetting issues, is still relatively unstable under some conditions. In addition, the vertical anisotropy (ratio of the horizontal K to the vertical K) is 100 in most of the zones (and still 50 in the remainder). This suggests, in light of the relatively high horizontal Ks, that there is sufficient fine-grained inter-bedding or more extensive contiguous zones that may inhibit vertical migration as a part of the conceptual site model as may be incorporated into the model. Further vertical discretization may provide some additional detail that could be built into the model and improve the fit to observed conditions.

5.2 STORAGE, SPECIFIC YIELD AND POROSITY

The FFS calibrated model GWV file contains a database of 10 different zones characterizing aquifer porosity and storage properties. Storage coefficients varied from 0.0000025 to 0.0000034, specific yield from 0.02 to 0.18, and porosity (used as effective) constant throughout the model at 0.25. These factors will influence volumes in and out of storage in transient mode, but will tend to become less important under longer periods of relatively steady stress conditions. MODPATH, the particle tracking code, will use the effective porosity to compute velocities and travel times. In the NHOU area, the predominant values of storage, specific yield, and porosity are 0.0000025, 0.17, and 0.25 in model layer 1, and 0.0000031, 0.1, and 0.25 in model layer 2, for storage coefficient, specific yield, and effective porosity, respectively. Values of specific yield for the lower model layers probably do not come into play as those layers likely remain fully saturated and confined during simulations. Values for the storage coefficient appear to be about two orders of magnitude too low, and these may be specific storage values rather than confined storage coefficient. Using the lower values would cause the drawdowns to propagate faster, but have little effect in long-term steady stress simulations.

Values for storage coefficient and specific yield were retained for zones in the alternatives simulations, but the effective porosity was reduced to 0.15. While this is consistent between the alternatives runs, it is different from the calibrated model. Particle tracks would look somewhat different for a transient run with 0.15 versus one with 0.25; no reason was given for this change.

5.3 INITIAL HEADS

Model documentation (CH2M Hill, 1994) indicates that some steady-state model runs were made to match conditions of relatively small storage changes in the SFB during 1982 and 1990, and that transient calibration proceeded from there. However, in the next section of that report it is stated that the initial head conditions were derived from digitizing the ULARA Watermaster report basin contours for autumn 1981. These contours were carried vertically through the depth regions (model layers) since no data were available to otherwise specify. Initial heads for the SFBFS model are contained in the GWV file as matrices and inserted into the MODFLOW Basic (.bas) file when the MODFLOW input files are generated by GWV.

6.0 MODEL CALIBRATIONS AND SENSITIVITY

6.1 MODEL SOLVER

Several solver packages are available for MODFLOW model equation solution. The MODFLOW-SURFACT package typically uses a preconditioned conjugate gradient (PCG) solver which is more suited for non-linear equations. The PCG4 solver is the one more likely to have been used in earlier model runs, although an updated solver, PCG5, is now available as is MODFLOW-SURFACT version 3 (Amec Foster Wheeler upgraded to the newer versions). The files for the Glendale model indicate that that model has been most recently run using MODFLOW-SURFACT version 3 with the PCG5 solver. Parameters may be adjusted within the solver input parameters to aid in the convergence of the solver to a prescribed allowable maximum head difference at nodes between solver iterations. We note that the head closure criterion for the FFS calibration model was 0.1 feet, and was 0.3 feet for the simulations of alternatives. The Glendale model had an even greater head closure criterion of 1 foot. These all would be considered large (typically a head closure criterion is 0.01 foot or less), but appears to have been necessary to allow solver convergence. The PCG4 solver was set for maximums of 200 outer iterations and 500 inner iterations. Even though MODFLOW-

SURFACT was developed to cope with situations of inherent instability due to drying and rewetting of model cells, the present model still has residual instability which may be severe in certain conditions, i.e., cause the model not to converge. A second solver input parameter (BFACT) seems to have been varied, and was set to 0.05 for the FFS calibration model and 0.15 for each of the simulations. Use of a larger head closure criterion may lead to some error in the solution heads as progress to convergence is not necessarily monotonic and some relatively random computed head may trigger convergence before the head matrix has achieved a true equilibrium; however, this may be acceptable (if errors are small) or even necessary in achieving convergence. This factor will need to be evaluated further when conducting recalibration or simulations in support of the design.

6.2 CALIBRATION

Calibration of the model included matching observed hydraulic gradients, target water level matches, optimizing residuals analyses, and matching with hydrographs of other selected observation wells in addition to the target data set. The calibration was performed in transient mode, with a target data set covering an overall period of 25 years (water years 1981-82 through 2005-06). Not all target observation well locations have data spanning the entire calibration period. Appendix B of the FFS indicates that the target water calibration data set for the earlier model was augmented with water level data from other areas than NHOU, especially in the Burbank, Glendale, and Crystal Springs areas (see Figure B-2 of Appendix B of the FFS; USEPA, 2009a). However, only water level data for a stated 34 target wells were entered in the NHOU FFS calibrated model files posted on the CH2M Hill FTP site. Many of these are situated in and nearby NHOU, and thereby provide a focused view of model fit in the NHOU area. Further, review has indicated that data for four wells was repeated, and that two wells occupied the same horizontal and vertical model node (observed heads at each of the wells would then be compared with a single model output head value). This would tend to bias the results of the statistical analysis of residuals. The NHOU target observation wells contained within the model files provided are listed in Table A-1a. The rationale and sufficiency of the selected target data set was not discussed, but this may represent a run to observe residuals and model fit in just the NHOU area. Target observation well locations for the model calibration for this limited data set are shown on Figures A-8, A-9, A-10, and A-11. The GWV contoured output heads for model layer 1 are shown on Figure A-12. Attachment 2 shows hydrographs of observed and computed heads for the wells in the NHOU-limited target data set. Some greater sources of the error in the model are suggested by stretches of data where the observed and computed differ by 5 feet or more, anomalous data points that would lead to large residuals, and intervals in the data record where observed heads vary wildly over short periods of time. A scatter plot of model computed heads versus observed heads are shown on Figure A-14a.

It is assumed that the SFBFS model was calibrated to a larger target water level data set consistent with that contained within the Glendale model files. Hence, these targets were extracted from the Glendale model file and imported into the SFBFS-B calibrated model (see Table A-1b). The transient SFBFS calibration model run began with an initial average head condition. Overall disperse recharge was maintained constant as were the influxes from the adjacent sub-basins (e.g., Sylmar and Eagle Rock). Data obtained from the ULARA Watermaster and other sources were used to quantify recharge derived through the spreading basins as well as water withdrawn throughout the SFB by extraction and production wells. The transient model run consisted of 100 equal stress periods (a time over which all stress [e.g., well pumping rates] and boundary conditions remain the same) over 25 years. This represented an extended period of observation over the previous calibration (i.e., from 1981 to 1999 to 1981 through 2006). Each stress period consisted of only one time step. Since this is a transient run, water into and/or out of storage can be a significant component of the overall water balance. The well extraction rates and the spreading basin contributions have been entered into the model as quarterly averages. This averaging and coarse time stepping may introduce some error in matching short-term groundwater level measurements used in the calibration.

Appendix B of the FFS (USEPA, 2009a) stated that significant differences between observed and model computed water levels existed for the extended calibration period which led to a further calibration refinement. This was achieved primarily by: 1) increasing vertical and horizontal Ks throughout the model by 50 percent; 2) increasing the conductance of the river nodes by a factor of 5 in the Los Angeles River narrows area; and 3) eliminating a small zone of model elements with low assigned K values trending east-west within model layer 2, north of the Narrows.

The model was stated as being sufficiently calibrated for the purposes of the FFS. The overall (all layers, all times) resultant residual statistics are presented in Table A-2a. Table A-2b shows the residuals statistics for each model layer for the entire simulation. Table A-2c shows how the residuals statistics change over time, and how the number of target water levels decrease over succeeding time period (less water level data is being collected over time). The model typically underestimates the actual water table elevation by an average of about 7 feet in the target location area, while extremes occur within the model domain that result in under- or over-prediction of heads by as much as 40 feet.

In one exercise, Amec Foster Wheeler has used the SFBFS-B calibrated model for additional runs in which the hydraulic conductivities in all layers were uniformly decreased by 10 percent, and then increased successively by 10 and 20 percent. The results of these runs relative to the goodness-of-fit statistics are also presented on Table A-2a. These results suggest that further adjustment of the model in the NHOU area to improve goodness-of-fit is possible. Note that this overall approach is rather coarse, and that better fits might be obtained by adjustments of individual zone parameter values rather than a mass adjustment of all zones, especially when focusing on a particular areas as will need to be done for the NHOU design.

While the overall calibration would be rated as satisfactory, there are, nonetheless, large residual values (Tables A-2a, A-2b, and A-2c). These should be closely examined to assure that the model computed heads and resultant gradients in the vicinity of the NHE extraction wells are reasonable and do not bias flow to one set of production wells versus another. Spatial bias in the residuals is discussed further later in this section.

As indicated previously, the Glendale model files were also downloaded. Inspection indicated that the Groundwater Vista file contained target water level data for 88 target observation locations. These targets were exported from the Glendale model, merged with those for the NHOU FFS model, reformatted, and imported into the FFS model, resulting in 92 target locations. Residual statistics were extracted from Groundwater Vistas and are included on Tables A-2d and A-2e. These measures indicate a much better overall fit overall and for each layer than when only the NHOU targets are used. The calibration of the SFBFS model used the more complete set of target locations as evidenced by the array of hydrographs of observed versus computer generated water piezometric heads included in Appendix B of the FFS.

In addition, Amec Foster Wheeler used the SFBFS model, which contained data extending into 2006, to include target locations from the Glendale model and enter data for four additional years (up through the water year 2009-2010) for production well, extraction well, spreading grounds, and target water level data, also adding data from newly installed wells, bringing the total number of target observation locations to 118 (see Table 1b). As part of this process, anomalous water level readings were deleted from the record of some wells included in the model. The vast majority of the water level targets are located in the southeast portion of the model as reflects the concern with water supply wells and the investigations to determine the extent of contaminants in the vicinity of the production wells. With the available water level dating back to 1981 (the start of the transient calibration model), the updated water level target data set has 10,294 entries. Results from this extended run are included on Figure 13 and residuals measures on Tables A-2f and A-2g.

There is an obvious bias to the location of the majority of the target data water levels. These are logically located in the eastern portion of the basin as most well fields are located here, and this has generated the level of concern that has resulted in many investigations and monitoring well installations. Some exceptions are a few wells installed for the RI. This is not a significant detriment as the focus of the remedial activities related to NHOU are within this area of greater data density and provides data for defining the aquifer response to the major pumping and recharge centers.

There is a spatial bias in the distribution of residuals, with positive residuals (model too low) predominantly throughout the NHOU area and negative residuals (model too high) predominantly throughout the Crystal Springs and Pollock areas (Glendale and south through the Los Angeles River Narrows). Table A-3a shows residuals for the target data set organized first by model layer and then by Sum of the Square of the Residuals (i.e., typically large standard deviation, but also dependent on the number of transient target water levels for each target location). The locations with the greatest average deviation and/or standard deviation contribute most to the overall goodness of fit factors (e.g., well 3813J in model layer 1). Because the newly (2009/2010) wells have only been measured once within the calibration simulation period, these are set out separately in Table A-3b. The average residual and standard deviation for each location have been hand-posted on figures of location for each of the model layers in Attachment 3, and these illustrate the spatial bias of the residuals. This spatial distribution suggests that the model hydraulic conductivity may be too high in the NHOU area and too low in the Crystal Springs and Pollock area (at least relatively). The residuals may also be affected by boundary conditions, e.g., the river stage and conductance through the Crystal Springs and Pollock areas, and the effects of faults in the north and in the Narrows. The results of newly installed wells in the NHOU area show less bias, but this is based only on one data point available during the calibration simulation period. It will take time to see if these locations develop a more consistent bias or not.

The effect of this bias may be that the model may underestimate both the available saturated thickness at the NHE wells and the capture zone established by a single well operating at a given pumping rate. This could greatly affect the proposed location, depth, and operating rates of proposed wells in the design of a more optimal Second Interim Remedy.

With the large number of target data points, a single anomaly (even extended over time for a location) is engulfed by the sheer number of data points, and changes in the mean residual or the normalized standard deviation will remain adequate in terms of a goodness of fit based on residuals. Improvement to the model with respect to residuals needs to focus on the absolute residual and/or standard deviation in addition to matches over time for the select hydrographs and matches with observed gradients and flow directions. This is made more difficult in a transient calibration mode when dates of observation may not coincide with model computed heads at specified regular time steps, and the fact that on a year to year basis, the SFB is such a dynamic system. This is discussed more in the next section on sensitivity.

6.3 SENSITIVITIES IN THE MODEL

A preliminary sensitivity analysis was performed to get an idea of potential primary parameter values to vary in the recalibration of the potentially modified model prior to undertaking design-related simulations. Parameters selected included: hydraulic conductivity assigned to select and fairly extensive zones in and downgradient of the NHOU for each of the four model layers;

uniform overall increases and decreases of hydraulic conductivity in each of the model layers; overall increases and decreases in recharge; and select zones of specific yield covering large areas in model layer 1.

6.3.1 Sensitivity to Hydraulic Conductivity

As reflected in the changes in residual statistics, the model was generally relatively insensitive to changes in hydraulic conductivity in one zone, even if the zone was relatively large. For most selected zones, the residual statistics indicated that the calibrated model values represented a reasonable minimum (i.e., changing the value of the hydraulic conductivity in either direction resulted in a worsening of the residuals). There were a few exceptions, but even with improvements in some measures, the absolute mean and the standard deviation remained relatively unchanged. The normalized standard deviation, the standard deviation divided by the range of the observed water level measurements, remained relatively low and stable since the range of the observed water levels was over 200 feet over the model domain, so the ratio remained small (typically a normalized ratio of 0.1 or less is indicative of a reasonably calibrated model). Changing the hydraulic conductivity of a model layer proportionately (multiplying the hydraulic conductivity of all zones in the layer) did result in appreciable changes to the statistical measures, and it may be this effect that spurred the uniform adjustment of the hydraulic conductivity for the FFS. A summary of the sensitivity analysis to hydraulic conductivity is presented in Table A-4a.

This relative insensitivity of the model statistical measures to hydraulic conductivity was further emphasized in another exercise spurred by one description of the SFB as one large, relatively uniform hydrogeologic unit (at least in reference to either the east or west portions of the basin. Amec Foster Wheeler made the simplest of assumptions for distribution of hydraulic conductivity, using only three zones. One value (26 ft/d) was assigned to the east and one (128 ft/d) to the west portion of the basin (see Figure A-15), which were carried down through model layers 2 and 3, and then assigned a third value (16 ft/d) to all of the deep aquifer, i.e., model layer 4. A representative value was selected for each zone, and without further attempts to optimize these values, a reasonable array of statistical parameter values was obtained for the residuals that was comparable to the SFBFS-B calibrated model (see Table 4b). This suggests that the with the high hydraulic conductivities in the SFB, that the model is basically responding to the inputs of recharge and spreading grounds and the withdrawal of production and extraction wells in a very uniform manner. The large standard deviation and mean absolute residual may be due to several factors, including: significantly variable water levels at some locations (e.g., NH-C04-375); inability of the model to represent conditions at a particular location with consistent and significant deviation (e.g., LB6-MW01); errors in well screen specification; large convergence criteria; quarterly averaging of input/output stresses; and use of a long-term average, constant recharge estimate. These factors will need to be considered in any refinements and future use of the model.

These results suggest that even substantial changes in the calibrated model hydraulic conductivity values for a single zone, even a fairly large one, may not result in significant changes in residual statistics. What is more important to the goals of the model in support of design is that local gradients and hydraulic conductivity values local to the area of the proposed modifications are reasonable and groundwater flow directions are reasonably represented in response to local or nearby stresses (i.e., that capture zones for wells may be reasonably estimated based on the model inputs).

6.3.2 Sensitivity to Recharge

Recharge, the amount of infiltration that percolates though the vadose zone and reaches the water table, is assigned in the model as variable across the SFB due to greater runoff from mountain areas around the perimeter of the model domain and lower rates across the valley that reflects both the lesser precipitation as compared to the mountain areas, but also to the effects of urbanization that restricts recharge by inducing run-off to contained conveyances. SFB Water Management Plans are on-going to improve the amount of precipitation that is introduced to the SFV storage, e.g., improving the efficiency of the spreading grounds. While variable across the model domain, the diffuse recharge is applied as a constant through time (i.e., the recharge rate does not vary from one stress period to the next). This was discussed in Section 4.6. Varying the recharge for sensitivity purposes can be easily achieved by manipulating the multiplier of the MODFLOW recharge package matrix. The recharge was varied by increases and decreases by factors of 1.1 and 1.2. The model is very sensitive to variation in recharge as shown toward the end of Table A-4a, resulting in changes of about 6 feet in the average residual for each step in the factors applied. Surprisingly, the increase in recharge of 10 percent resulted in an unstable condition and the model failed to converge (200 outer flow iterations of the PCG5 solver) in Stress Period 59. Steps may be taken to eliminate this anomaly and achieve convergence, but this was not attempted at this point.

6.3.3 Sensitivity to Specific Yield

Specific yield is important in a transient simulation of unconfined aquifer conditions as it moderates the rate at which the water table fluctuates (or of deeper layers if wells can create sufficient drawdown). In the calibrated model, there are two principal zones with assigned values in model layer 1. These are 0.17 (Zone 6) for much of the NHOU and Burbank areas, and a similar value of 0.18 (Zone 7) extending from south Burbank through Glendale and into the LA River Narrows. A constant value of 0.1 has been assigned to each of model layers 2, 3, and 4. In this sensitivity exercise, the values assigned to Zones 6 and 7 were individually (one at a time) increased and decreased by factors of 1.25 and 1.5, giving a range of .113 to .255 for Zone 6 and similarly for Zone 7. The model seemed somewhat sensitive to the variation in Zone 6, with the residuals becoming better as the value increased. The model was only slightly sensitive to changes in Zone 7 values, and seemed best at the 0.18 assigned value. (See end of Table A-4a for summary of sensitivity to specific yield.)

6.3.4 Sensitivity to Changes in Screened Interval

As described in Section 4.5.5, there were many apparent discrepancies in the screened intervals of the production wells as reported in the USEPA database and those assigned to the analytical well approach in the SFBFS-B groundwater model (see also Attachment 1). An alternate well specification import file was prepared using the USEPA database values. Some of these were only slightly different than in the model, but others were much greater. However, depending on the amount of variation and the vertical positioning (mostly affecting screened intervals in model layer 1), the resultant effect in the model could be relatively insignificant. Indeed, the change in point-wise residual statistics was very small. However, local effects could still be significant, and the model should be examined closely in the NHOU area to assure that changes here are also relatively insignificant, or that changes to the well package should be applied. (See Table A-4b for the change in residual statistics to this modification.)

6.3.5 Sensitivity to a Fault Zone

Throughout the many descriptions of the geologic features in the SFB that may affect groundwater flow, the presence of fault zones (e.g., the Verdugo, Northridge Hills, Mission Hills, and Raymond Faults) receives much attention. In the JMM modeling for the RI, the presence of fault zones was included by assigning sharp differences to model grid blocks straddling and approximating the line of the fault. As the model became refined over the years, the inclusion of faults seemed to have been removed, with the Raymond Fault being deleted in the FFS model modifications and runs. However, the Verdugo Fault Zone lies in the vicinity of the NHOU area and is quite long. MWH has included the Verdugo Fault in their version of the model and states that this has improved the overall fit of the model, especially when looking at the Bradley Landfill monitoring well water levels (citation). The key here is that determination of the effects of the inclusion of the fault as measured by changes in the residual statistics depends on having some wells on either side of the fault with water level data. Looking at the residuals with the inclusion of the Fault (see Figure A-16) using the MODFLOW horizontal flow barrier package, it does not appear to have a significant effect on the resultant water levels through the NHOU (see Table A-4b), but this needs to be more fully examined during the modification and recalibration of the model, particularly if added well coverage is needed to the east. Another factor is that the distance between the Verdugo Fault line and the present NHE wells is substantial, and that although the fault may slow the effects of mountain runoff in the NHOU area, it may be too distant to really affect capture zones for NHE extraction wells.

6.3.6 Other Considerations

The other major factor in the modeling for the Second Interim Remedy design support is that a plausible and reasonable forecast of conditions in the SFB is available for simulations of well depths, locations, and pumping rates with respect to other demands on the basin aquifer storage. Overly conservative forecasts may result in an overly extensive and costly remedial system that may never be fully utilized, or one that is too inefficient to be cost-effective, or one that may actually exacerbate the current contaminant potential impacts rather than effectively contain or remediate them.

7.0 SIMULATIONS OF ALTERNATIVES

Simulations were performed with the SFBFS model to support evaluations of alternatives considered for the FFS. Included for review were alternatives that dealt with updating existing NHE extraction wells and the addition of three new extraction wells to further guard against migration to the southern wells of the Rinaldi-Toluca well field, and with no further action (NFA) for both average expected conditions and for dry expected conditions. The simulations were run for a period of 2007 through 2017 based on two estimated forecast water demand conditions for the SFB as provided by the ULARA Watermaster.

Attachment 4 contains a copy of the estimated forecast conditions for future water years 2006-2007 through 2016-2017 as found in the Administrative Record (item SDMS DOCID# 1117518). These sets of conditions appear to be generated by reversing the order of conditions (dry or normal years) as experienced in water years 1993-1994 to 2003-2004, e.g., the conditions for 2016-2017 were taken as similar to those in 1993-1994, a year with a below average rainfall. When a year had less than average rainfall, a maximum withdrawal of production wells was assumed (about 142,000 acre-feet per year), with the variable spreading ground input. This forecast included both normal and dry years. In a normal year, the withdrawal rate was assumed to be about 107,120 acre-feet per year. A second scenario was created by assigning both average recharge and spreading ground input, and production well withdrawals for each of the simulated years. In the model simulations, the rates applied are slightly different. In the dry year's simulation, production/extraction rates are approximately 133,000 acre-feet per year for a dry year, and in the normal year. The spreading ground recharge is variable, averaging about 25,400 acre-feet per year. In the average conditions simulation, the model inputs are spreading grounds at 31,000 acre-feet per year, and about 98,000 acre-feet per year production/extraction. In all simulations, the diffuse recharge is approximately 57,400 acre-feet per year.

Of note is the dramatic decrease in the projected water level in the NHOU area even under assumed average future conditions. At the end of the simulation (corresponding to about 2017) of the no further action scenario, the water table had fallen about 30 to 40 feet in the NHE well area. It might be anticipated that even further extension of these conditions through time would result in Depth Region 1 becoming dry throughout much of the basin (see Figures 17 and 18). The projected conditions including dry period with accompanying increases groundwater demand are even more severe (see Figures A-19 and A-20). The assumption of continued imperilment of the basin storage capacity, then, has severe implications for the future operation of wells in the NHOU which are focused on controlling migration and removing the greater contaminant mass in the shallow aquifer (Depth Region 1). In reviewing the actual water levels in the SFB over 2006-2010, it is clear that the projected declines have not materialized, mainly due to restrictions posed by the presence of contaminants at many production well locations and their closure. Further, there is a concerted effort to improve the storage conditions in the SFB through water management programs including water recycling, improved infiltration through the spreading grounds, restoration of an appropriate safe yield withdrawal, and water conservation.

The groundwater modeling simulations conducted for the FFS were based on very conservative projections of future SFB conditions in which withdrawals considerably exceeded inputs from recharge and the spreading grounds. These conditions applied in the model produced significant lowering of the water table throughout Depth Region 1 over much of the central portion of the model domain. As a result of the 2008 Stipulated Agreement ("Interim Agreement for the Preservation of the San Fernando Basin Water Supply") to limit withdrawals and return the SFB to safe yield conditions, the five Parties (Cities of Los Angeles, Burbank, Glendale, and San Fernando, and the Crescenta Valley Water District) to the agreement have begun to restrict withdrawals and have promoted projects to increase recharge of run-off, increase use of recycled water, improve the scope and effectiveness of spreading grounds use, and institute water conservation awareness in the SFB communities. As part of the Agreement, each participating entity produces a 5-year projection plan for groundwater use. These plans are combined in an annual ULARA Watermaster Groundwater Pumping and Spreading Plan. The July 2011 Plan, covering the 2010-1015 Water Years (see Attachment 5), indicates that with the implementation of current plans and proposed projects, that the SFB will see an increase in storage of 310,913 acre-feet over the next 5 years, and that increases in the water table elevation of about 50 feet will occur in the NHOU area. These goals also appear in the LADWP 2010 Urban Water Management Plan, where SFB projected withdrawals for even multi-year dry weather conditions are cited as 92,000 acre-feet. This obviously has significant implications for the design of the 2nd Interim Remedy. Projections with respect to anticipated design basin conditions must be based on more realistic consideration of both future demand and the effects of the water management practices to maintain, if not restore to safe yield storage levels, current water level conditions within the basin.

Particle tracking to determine adequacy of capture zones was conducted by placing particles at the interpreted maximum contaminant levels (MCLs) and 10 times MCL lateral plume extents in model layers 1 and 2, but only at one depth (midpoint) of each layer. Model layer 2 is typically over 100 feet thick, so inferred capture zones are coarse over this interval (may be overly conservative). Simulations of projected conditions were based on 2007 estimates.

These need to be updated and other recent or projected stresses need to be included in future projections (e.g., remedial groundwater measures at the former Bendix facility). The appropriate source of the projections should likely be the ULARA Watermaster.

Results of the simulations were discussed in Section 4 of the FFS and consisted mainly of particle tracks for the alternatives, with initial particle locations corresponding to estimated envelopes of the VOC and chromium plumes as defined by the 5 and 50 microgram per liter contours for each and for model layers 1 and 2 [see, for example, Figures 4-15 (average conditions) and 4-17 (maximum pumping/dry conditions) of the FFS included here as Attachment 6]. Other aspects specific to each simulation run of the four runs provided are discussed below. Tables A-5a to A-5d list pumping rates attributed to the NHE existing and proposed three new wells for each of the four simulation runs at the first time step of the simulation and at the end of each stress period. In these tables, cells are color coded to indicate which wells and at what times the NHOU extraction well pumping rate is affected by the changes in the water table elevation. Tables A-6a to A-6d summarize the water balance quantities for each of the simulation runs. These tables show swings in storage, spreading basin amounts, and pumping under each of the simulation stress period assumptions.

It should be noted that the model and model simulations received challenges as technical comments and USEPA responses as contained in Appendix A of Part 3, Responsiveness Summary, of the USEPA Superfund Interim Action Record of Decision (ROD) for the NHOU (USEPA, 2009b). In summary, the USEPA conceded that the model may have some uncertainty and capture zones were based on conservative maximum detected concentrations from 2003 to 2007, but that it was adequate for the purposes of the FFS. The response to Comment 27 also indicated: “If new data collected prior to, or during, remedial design indicates that a different configuration of extraction wells is more effective and cost efficient than the configuration described in the Proposed Plan, then that different configuration will be considered for implementation as part of the Second Interim Remedy.”

7.1 ALTERNATIVE 2-4, AVERAGE CONDITIONS

This alternative includes deepening of some NHE wells (or replacement with deeper wells), addition of three new deep wells, with average projected withdrawal and spreading basin recharge over an 11-year period (2007 through 2017). In the proposed alternative, and as represented in the model run for this plan, NHE-1 would be deepened by about 125 feet, NHE-2 by 100 feet, NHE-4 by 120 feet, and NHE-5 by about 135 feet (or replacement wells completed to these depths). Although the FFS suggests that NHE-3 does not need to be deepened (and it may not), this well was the only well to incur a loss of the intended 250 gpm target flow rate in this simulation, beginning to drop in the fourth stress period (each stress period represents a simulated year), and falling to a zero rate by the end of the sixth stress period under the imposed future average conditions. NHE-3, NHE-7, and NHE-8 were the three wells pumping from the upper aquifer unit (model layer 1). In the simulation, although several of the other wells would be screened in model layers 1 and 2 or 1 through 3, pumping was assigned to the lowest unit screened (e.g., NEW001 in layer 2), and NHE-4 in model layer 3. It would seem likely that the upper units would also contribute flow and that capture would be better in the upper unit than portrayed. Total extraction rates drop only from an initial 3,050 gpm to 2,800 gpm (the 250 target gpm at NHE-3 was completely lost by the end of the sixth year). Areas in the model with dewatering in model layer 1 at the end of the simulation (2017) are shown on Figure A-17.

The particle tracking portrayed (i.e., in the FFS) is also somewhat at issue, although this is more a potential problem for the maximum yield (dry) runs. Some particles are seeded at distances from extraction wells such that the particle track shows capture by the well before it goes dry and suggests that the groundwater associated with the original particle location(s) would remain consistent to these completed pathlines through the course of the simulation.

7.2 ALTERNATIVE 2-4, DRY CONDITIONS

This simulation run was based on the same well configurations as the average condition run and had the same extraction well target flow rates (250 gpm for each existing NHOU extraction well, and 350 gpm for each of the three USEPA proposed new wells). Over the course of the simulation, each of the three wells screened only in the upper aquifer (model layer 1) goes dry, reducing the initial 3,050 gpm to 2,300 gpm by the end of the simulation. At the end of the simulation time, the model projects that much of the upper aquifer in the NHOU area could become dry (water table elevation below the bottom of model layer one – see Figure A-18).

The particle tracks appear more tortuous in this simulation run than in the previous average conditions run due to the more significant changes in model input and output stresses as well as the loss of some of the shallow well extractions. Many of the particles must migrate vertically downward into the lower aquifers before being captured. As discussed above, some of the apparent captured particles occur in the early part of the simulation and do not describe groundwater flow patterns in the latter part of the simulation.

7.3 NO FURTHER ACTION, AVERAGE CONDITIONS

In this simulation run, current NHOU extraction wells are simulated as maintaining their current screened length and the then current (2007) pumping rates. Average conditions of expected well field withdrawals and average spreading basin recharge are applied through the simulation period. The initial rates totaled 842 gpm, and by the end of the simulation, the total pumping rate had decreased to 670 gpm with the loss of pumping from NHE-3 and NHE-5. Although there is some pumping lost over the simulation period, particle tracks are relatively smooth (i.e., follow a consistent groundwater flow direction). Figure A-19 shows computed head contours and dry areas of model layer 1 for the end of this simulation run. As noted previously, water levels in the vicinity of the NHOU decline about 30 to 40 feet over the course of the simulation, with potential effects on the future ability of these wells to perform at design capacities.

7.4 NO FURTHER ACTION, DRY CONDITIONS

In this simulation run, current NHOU extraction wells are simulated as maintaining their current screened length and current (2007) pumping rates. As in the Alternative 2-4 Dry condition run, well field production rates are higher, but variable over the simulation period, while the spreading basin recharge is variable but consistently lower than average. The initial rates totaled 842 gpm, and by the end of the simulation, the total pumping rate had decreased to 163 gpm with the loss of pumping from all wells screened in Depth Region 1 (the only pumping well remaining on is NHE-6, screened down into Depth Region 2). Despite this decrease in Depth Region 1 pumping, much of Depth Region 1 is dry across the NHOU area by the end of the simulation period. Particle tracks are erratic as the layer dries up and wells turn off during the course of the simulation. Figure A-20 shows computed head contours and dry areas of model layer 1 for the end of this simulation run.

8.0 OBSERVATIONS ON THE GLENDALE MODEL

Briefly, this model covers the same model domain as the SFBFS-B model. However, it is more coarsely gridded having only 73 rows and 89 columns. Refinement is limited to the area of wells 4909L and 4909M where model cell size is still on the order of 250 by 180 feet. The calibration relied on 88 water level target locations rather than the 34 for the SFBFS-B model as provided on the web page, with many more of the targets located in the southeast corner of the model, closer to Glendale. As was the case for the SFBFS-B model, the residuals statistical measures vary over time (a 25-year transient period), and the number of available target water levels generally decreases with time (however, new wells have been installed by MWH which increase the coverage around and in the NHOU). The modeling was done using the GWV modeling platform and version 3 of MODFLOW-SURFACT. The model file was dated 4/21/2009. An accompanying report (CH2M Hill, 2010) indicates some revision to model hydraulic conductivities in the LA River Narrows based on pumping tests conducted there. This modeling focused on the Glendale South Operable Unit extraction wells. Fault zones do not appear to be considered in this model.

Closer comparison of the parameter values in this model versus the SFBFS-B model during revisions should be considered.

9.0 SUMMARY OF OBSERVATIONS OR INCONSISTENCIES ON THE SFBFS-B MODEL

Listed below is a summary of the comments regarding the model that have been mentioned in the previous review sections.

- While the model grid horizontal spacing has been refined to about 50 feet in the vicinity of the NHE extraction wells, the block averaging of computed head in the extraction well nodes may still underestimate local gradients and drawdowns, and produce inaccurate pathlines.
- Model coordinates are not the same as those for the newer surveyed wells installed in 2009 and for available recent shape files for the SFB and LA County (these may be converted, however).
- The head assigned to the constant head node in the model is not consistent between the FFS calibrated model and the simulations of alternatives. This change is not explained in the FFS model documentation.
- The well package has been used to simulate spreading basin flows to the SFB. Use of the recharge package might be more conceptually intuitive, but likely makes no significant difference in the model output.
- While natural recharge to the water table will be considerably delayed where the water table is very deep, the groundwater flow model cannot provide for this delay which will be variable as is the actual amount of precipitation that infiltrates and reaches the water table. The same is true for the spreading basins, although here the soil may be more fully saturated beneath the basins and the delay less. Hence the approach taken is reasonable, but will introduce error in the computation of the water levels, or a possible lag between the observed and computed head time series graphs.
- Production wells in the SFB are represented in the model using an analytical well and fractured well package (MODFLOW-SURFACT) approach. Model results should be evaluated to assure that this representation is appropriate in simulations.
- Review of data for screened interval elevations for existing extraction or production wells indicate that many of the entries in the model do not agree with data in the EPA database. While not all well construction data (ground surface or reference elevation) were available for calculating screen interval elevations, many of the pumping wells in the simulations had different screened intervals entered into the model than contained in the EPA database. A problem for some wells is the large number of perforated intervals in the production or extraction wells. A further examination of these data is in order.
- Use of the bottom of the well screen as a cut-off may overestimate the ability of the well to produce the target flow rates, particularly for wells screened in Depth Region 1 where the saturated thickness of the screen may become relatively small and drawdowns large relative to the aquifer thickness.
- The model has previously simulated effects of faults within the SFB, particularly in the LA River Narrows using low K nodes. The more extensive Verdugo Fault was not included. Use of the HFB package in would be a better representation of the effects of faults.

- Model layers as they exist in the SFBFS-B model are likely insufficiently discretized for purposes of supporting the project design. Subdivision of model layers 1 and 2 may be likely required to better represent the shallow aquifer characteristics, determination of proposed well depths, and representation of interpreted plume extents and target capture zones.
- The total number of K zones defined and used in the model seems somewhat excessive given the sometimes very slight difference in values ascribed to the zones. This may make recalibration more difficult, but may be specified to promote easterly flow through the basin without reference to any possible anisotropy and to provide gradational changes in the hydraulic conductivity distribution to lessen chances for model instability.
- Values for the storage coefficient appear to be about two orders of magnitude too low, and these may be specific storage values rather than confined storage coefficient. Using the lower values would cause the drawdowns to propagate faster, but have little effect in long-term steady stress simulations.
- The vertical anisotropy (ratio of the horizontal K to the vertical K) is 100 in most of the zones. This suggests, in light of the relatively high horizontal Ks, the there are sufficient fine-grained inter-bedding or more extensive contiguous lower K zones that may inhibit vertical migration. This may be some of the additional detail that could be built into the model to support design.
- Values for storage coefficient and specific yield were retained for zones in the alternatives simulations, but the effective porosity was reduced to 0.15. While this is consistent between the alternatives runs, it is different from the calibrated model. Particle tracks would look somewhat different for a run with 0.15 versus one with 0.25; no reason was given for this change.
- Use of a relatively large head closure criterion for the solver in the alternatives simulations may lead to some error in the solution heads, but may be acceptable or necessary in achieving convergence. This will need to be evaluated further when conducting recalibration or simulations in support of the design.
- Model calibration is to 25 years of water level data for a selected number of monitoring well nests. It appears that some of these locations may have been repeated in the target input data corresponding to the NHOU wells (cluster set NH-C01 seems to have been duplicated). In addition, two nested wells reside in the same node and model layer. This is likely to produce bias in the comparison to model results. Additional layering may resolve this latter situation.
- The well extraction rates and the spreading basin contributions have been entered into the model as quarterly averages. This averaging and coarse time stepping may introduce some error in matching short-term groundwater level measurements used in the calibration.
- Any model is a simplification of the true system, and small-scale heterogeneity detail cannot be captured. Also, due to uncertainty in the delay of both natural and spreading basin recharge to reach the water table, there will always be some measure of error in the model that needs to be considered in interpreting the results of the model.
- Target water level data contained in the Glendale model were excerpted and entered as target data for the FFS model. The inclusion of these data improved the

overall model fit greatly; however, the larger residuals would still exist for the NHOU area. Some anomalous values in the FFS model water level data may detract from the apparent goodness-of-fit.

- Residuals analysis on additional model runs, varying model hydraulic conductivity overall throughout the model suggests there is still room for improvement through further calibration in the NHOU area.
- The spatial distribution of residuals in the model is extremely biased to high residuals in the NHOU area (model heads too low) and low (negative) residuals in the Crystal Springs and Pollock areas (model heads too high). This may indicate too high an assigned hydraulic conductivity in the NHOU area, which may affect simulation of correct capture zones and result in a less than optimal design.
- Some of the residuals suggest possible effects of boundary conditions, such as the Los Angeles River, and the lack of inclusion in the model, such as faults. Other residuals suggest possible water level measurement error or survey error in reference elevations.
- Residual errors should be closely examined to assure that the model computed heads and resultant gradients in the vicinity of the NHE extraction wells are reasonable and do not bias flow to one set of wells versus another.
- The model appears relatively insensitive to reasonable changes in individual hydraulic conductivity zone values. It is more sensitive to changes throughout an entire layer.
- The model was very sensitive to variation in recharge, and somewhat sensitive to variation in specific yield in model layer 1.
- The model was relatively insensitive on a basin-wide scale to the inclusion of the Verdugo Fault or revisions to the screened intervals assigned to the analytical well package based on data in the USEPA database as reflected in modest changes in the resultant residual statistical measures. These still need to be examined more closely on potential local changes in the NHOU area.
- Particle tracking to determine adequacy of capture zones was conducted by placing particles at the interpreted MCL and 10 times MCL lateral plume extents in model layers 1 and 2, but only at one depth (midpoint) of each layer. Model layer 2 is typically over 100 feet thick, so inferred capture zones are coarse over this interval (may be overly conservative).
- •Simulations of projected conditions were based on 2007 estimates of contaminant distribution extents. These need to be updated and other recent or projected stresses need to be included in future projections (e.g., remedial groundwater measures at the former Bendix facility).
- The groundwater modeling simulations conducted for the FFS were based on very conservative projections of future SFB conditions in which withdrawals considerably exceeded inputs from recharge and the spreading grounds.
- Projections of future groundwater use with respect to anticipated design basin conditions must be based on more realistic consideration of both future demand and the effects of the water management practices to maintain, if not restore to safe yield storage levels, current water level conditions within the basin.

- Closer comparison of the parameter values in the Glendale model versus the SFBFS-B model during any revisions should be considered.
- Results of the simulations for the Proposed Plan and the NFA alternative are subject to some uncertainty due to the factors in the model discussed previously and summarized here. Based on new data and further refinement of the model, it will be possible to further optimize the specifications for the modifications that will be required to achieve the RAOs with respect to groundwater containment and contaminant mass removal.

10.0 CONCLUSIONS

The FFS modeling is based on a model which is suited to basin-wide evaluation. The magnitude of residuals is several portions of the model, particularly in the NHOU area, raises questions about the ability of the model to accurately represent local gradients and capture zones for the existing NHE extraction wells and the proposed modifications to the system.

The model's simplified vertical discretization is not consistent with more recent data which has suggested an aquitard layer between the present conceptualization of Depth Regions 1 and 2. The model needs to incorporate a more refined vertical representation of the hydrogeology if the design is to rest on a firmer foundation.

The distribution of residuals in the model suggests that the assignment of hydraulic conductivity values over relatively large areas may be in error, and that the hydraulic conductivity assigned through the NHOU area may be too large leading to potentially underestimations in saturated aquifer thickness and the simulated capture zones for NHE wells (or their possible replacement or augmentation), leading to a less than optimal design for the Second Interim Remedy.

The relative insensitivity of the model to hydraulic conductivity within individual zones is likely a result of high hydraulic conductivities in the basin and the very large and transient stresses (pumping, recharge). This condition suggests that inferred capture zones may be over- or underestimated based on current assigned values of hydraulic conductivity and this will have a decided effect on the uncertainty of model projections of capture and on the preliminary Second Interim Remedy design.

The relatively bleak projection for demand in the SFB on the storage volume as reflected by modeled water levels (i.e., over 30-foot decreases) under an average projection (not including accommodation for dry years and increased demand), has severe implications for the design as well as future contaminant distribution and duration of the remedy. The projection for declining water level over the intervening years 2006-2010 has not materialized, and the water management plans for the basin should provide for a more secure and stable condition in the SFB. These factors need to be incorporated into a new, more realistic projection for the SFB as a basis for the proposed design of the Second Interim Remedy.

The several limitations of the current SFBFS-B model suggest a need to modify, refine, and recalibrate the existing model as a more accurate basis for design of the Second Interim Remedy. These modifications may include, but be not limited to, factors such as revised vertical discretization to incorporate a revised conceptual model and vertical distribution of contaminants, incorporating the several years of added data available since the SFBFS-B model was last modified and recalibrated, and adding and testing for the local influence of fault zones and the revision of specified screened intervals in the analytical well package currently in the model relative to data present in the USEPA database. The addition of other selected target observation locations should also be evaluated.

The goodness-of-fit statistical parameters may be one guide to the overall calibration, but simulations dealing with establishing capture zones should also be conducted with the understanding that this is not the whole story and that sensitivity analysis needs to be conducted to in order to provide some degree of assurance that the system will be flexible enough and of sufficient capacity to provide confidence in achieving RAO goals despite the level of uncertainty in the model parameters. There also needs to be in place a monitoring scheme sufficiently dense and accurate enough to verify capture with the interpretation of actual water level data.

11.0 REFERENCES

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TABLES

TABLE A1a

TARGET MONITORING WELLS
NHOU MONITORING LOCATIONS ONLY

North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

ID	Depth Region	ID	Depth Region
NH-C01-325	1	NH-C01-660	3
NH-C02-220	1	NH-C02-520	3
NH-C04-240	1	NH-C03-580	3
NH-C05-320	1	NH-C03-680	3
NH-VPB-02	1	NH-C04-560	3
NH-VPB-03	1		
NH-VPB-06	1	NH-C01-780	4
NH-VPB-07	1	NH-C02-681	4
NH-VPB-08	1	NH-C03-800	4
3811E	1		
3841H	1		
3894Z	1		
3948H	1		
NH-C01-450	2		
NH-C02-325	2		
NH-C03-380	2		
NH-C04-375	2		
NH-C05-460	2		
LB-MW-01	2		
3800A	2		
3863B	2		
3934B	2		

TABLE A1b

OBSERVATION LOCATIONS FOR EXTENDED FFS MODEL

North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

Depth Region 1				Depth Region 2		Depth Region 3	Depth Region 4
3811E	CS-VPB-05	NH-C04-240	NH-VPB-08	3800A	NH-C05-460	CS-C02-335	CS-C01-558
3813J	CS-VPB-06	NH-C05-320	NH-VPB-12	3852H	NH-C06-285	CS-C03-465	CS-C03-550
3830S	CS-VPB-07	# NH-C07-300	PO-C02-053	3862E	NH-C06-425	CS-C04-382	NH-C01-780
3841H	CS-VPB-08	# NH-C08-295	PO-VPB-02	3863B	# NH-C10-360	LB6-CW07	NH-C02-681
3852F	CS-VPB-09	# NH-C09-310	PO-VPB-05	3934B	# NH-C12-360	NH-C01-660	NH-C03-800
3860J	CS-VPB-10	# NH-C10-280	PO-VPB-08	CS-C01-285	# NH-C13-385	NH-C02-520	
3862D	CS-VPB-11	# NH-C11-295	V14WBRS1	CS-C02-250	# NH-C15-330	NH-C03-580	
3894Z	GNP-2	# NH-C12-280		CS-C03-325	# NH-C16-320	NH-C03-680	
3948H	GNP-3	# NH-C14-250		CS-C04-290	# NH-C16-390	NH-C04-560	
CS-C01-105	GNP-4	# NH-C15-240		CS-C05-290	# NH-C17-339	# NH-C22-460	
CS-C02-062	GNP-5	# NH-C17-255		CS-C06-278	# NH-C18-365	# NH-C22-600	
CS-C02-180	GNP-6	# NH-C18-270		GNP-1	# NH-C19-360		
CS-C03-100	GSP-2	# NH-C19-290		GSP-1	# NH-C20-380		
CS-C05-160	GSP-3	# NH-C21-260		LA1-CW02	# NH-C21-340		
CS-C06-185	GSP-4	NH-VPB-02		LB6-MW01	# NH-C22-360		
CS-VPB-01	GSP-5	NH-VPB-03		NH-C01-450	PO-C01-195		
CS-VPB-02	LC1-CW03	NH-VPB-04		NH-C02-325	PO-C01-354		
CS-VPB-03	NH-C01-325	NH-VPB-06		NH-C03-380	PO-C02-205		
CS-VPB-04	NH-C02-220	NH-VPB-07		NH-C04-375	PO-C03-182		

- well added for strss periods 101-116

TABLE A2a

SENSITIVITY OF RESIDUALS TO K
FFS MODEL (100SP) WITH JUST NHOU TARGETS

North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

Residual Measure	FFS Calib	with 0.9xKx	with 1.1xKx	with 1.1xKx,Kz	with 1.2x Kx
Mean	7.32	9.94	4.29	4.71	2.72
Absolute mean	10.27	12.29	8.25	8.51	7.48
Std dev	10.12	10.41	9.73	9.79	9.66
SSR	618,000	821,000	448,000	467,000	399,000
min	-40.97	-38.61	-44.93	-44.45	-46.96
max	91.6	95.22	87.21	87.71	85.09
range	211.6	211.6	211.6	211.6	211.6
Scaled Std Dev	0.048	0.049	0.046	0.046	0.046

TABLE A2b

RESIDUAL MEASURES BY MODEL LAYER
FFS MODEL (100SP) WITH JUST NHOU TARGETS
North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

Residual Measure	All	Layer 1	Layer 2	Layer 3	Layer 4
Mean	7.32	6.37	5.35	10.28	12.67
Absolute mean	10.27	9.65	9.93	11.08	12.7
Std dev	10.12	10.01	11.57	7.31	6.13
SSR	618,000	243,000	195,000	10,300	77,100
min	-40.97	-40.97	-40.89	-31.58	-1.3
max	91.6	95.22	31.31	27.05	43.33
range	211.6	211.6	126.9	82	78.3
Scaled Std Dev	0.048	0.047	0.091	0.089	0.078

TABLE A2c

RESIDUAL MEASURES DURING SIMULATION
FFS MODEL (100SP) WITH JUST NHOU TARGETS
North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

Residual Measure	5000 days *	6000 days *	7000 days *	8000 days *	8800 days *
Number	618	460	411	89	19
Mean	6.22	2.13	9.68	9.28	5.6
Absolute mean	8.67	5.61	10.76	9.28	6.63
Std dev	8.57	7.64	6.29	3.15	5.32
SSR	69,300	28,900	54,800	8,540	1,130
min	-33.31	-32.72	-33.28	2.83	-7.46
max	28.46	43.33	46.41	21.88	15.24
range	188.9	188	86.2	24.3	32.9
Scaled Std Dev	0.045	0.041	0.073	0.13	0.162

* Period covering residuals is plus/minus 365 days

TABLE A2d

RESIDUAL MEASURES BY MODEL LAYER
FFS MODEL (100SP) - ALL TARGETS

North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

Residual Measure	All	Layer 1	Layer 2	Layer 3	Layer 4
Mean	2.48	2.2	1.57	5.08	5.22
Absolute mean	8.26	7.75	7.81	10.92	10.7
Std dev	10.1	9.58	10.11	11.53	10.9
SSR	1,020,000	501,000	283,000	164,000	67,500
min	-135	-40.95	-35.26	-24.28	-14.32
max	46.41	46.41	31.51	35.84	30.89
range	224.33	224.03	211	111.16	100.11
Scaled Std Dev	0.045	0.043	0.048	0.104	0.109
Number	9,379	5,179	2,704	1,034	462

TABLE A2e

RESIDUAL MEASURES DURING SIMULATION
FFS MODEL (100SP) - ALL TARGETS
North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

Residual Measure	5000 days *	6000 days *	7000 days *	8000 days *	8800 days *
Number	1,446	1,146	1,141	410	250
Mean	2.11	-1.27	0.87	-1.92	-1.21
Absolute mean	7.35	5.66	7.76	8.83	5.03
Std dev	8.81	6.84	8.91	9.53	5.91
SSR	119,000	55,400	91,500	38,700	9,100
min	-33.35	-32.64	-33.17	-17.33	-13.27
max	24.03	22.11	46.21	21.91	15.24
range	224.2	200.61	192.93	165.13	176.71
Scaled Std Dev	0.039	0.034	0.046	0.058	0.033

* Period covering residuals is plus/minus 365 days

TABLE A2f

RESIDUAL MEASURES BY MODEL LAYER
FFS MODEL (116SP) - ALL TARGETS
North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

Residual Measure	All	Layer 1	Layer 2	Layer 3	Layer 4
Mean	1.6	1.42	0.54	4.17	4.32
Absolute mean	7.79	7.31	7.48	10.1	9.92
Std dev	9.64	9.8	9.73	10.99	10.41
SSR	984,000	486,000	280,000	154,000	63,000
min	-40.96	-40.96	-34.84	-15.59	-13.96
max	41.14	41.14	29.99	34.52	30.24
range	224.39	224.09	212.98	101.03	100.11
Scaled Std Dev	0.043	0.041	0.046	0.109	0.104
Number	10,294	5,735	2,947	1,116	496

TABLE A2g

RESIDUAL MEASURES DURING SIMULATION
FFS MODEL (116SP) - ALL TARGETS

North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

Residual Measure	5000 days *	6000 days *	7000 days *	8000 days *	9000 days *	10,000 days *
Number	1,441	1,144	1,137	409	539	412
Mean	1.82	-1.21	0.74	-2.36	-2.06	-3.4
Absolute mean	7.22	5.6	7.57	8.7	5.14	5.53
Std dev	8.66	6.73	8.65	9.32	6.04	6.25
SSR	113,000	53,500	85,800	37,800	21,900	20,900
min	-33.23	-32.28	-32.61	-17.3	-23.87	-21.45
max	23.22	21.98	17.79	20.87	15.3	11.77
range	224.2	200.61	177.31	165.13	185.46	182.7
Scaled Std Dev	0.039	0.034	0.049	0.056	0.033	0.034

* Period covering residuals is plus/minus 365 days

TABLE A3a

SUMMARY RESIDUAL STATISTICS FOR INDIVIDUAL WELLS
FFS CALIBRATED MODEL EXTENDED TO 116 STRESS PERIODS
North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

Well Name	X-coord	Y-coord	Model layer	SSR	number	average	std dev
3813J	4170557	4171157	1	45040	112	17.36	10.09
3984Z	4195074	4169971	1	43266	195	-12.68	7.84
LC1-CW03	4176698	4185801	1	31456	136	14.41	5.07
3841H	4178541	4180249	1	24243	197	9.83	5.16
V14WBRS1	4183316	4187335	1	20718	104	13.32	4.68
NH-VPB-12	4192339	4180119	1	19892	123	11.88	9.81
3811E	4170837	4180536	1	19325	193	7.39	6.76
NH-C04-240	4192627	4176864	1	17152	114	11.06	5.33
NH-VPB-03	4171307	4179000	1	16917	113	4.76	11.32
NH-C01-325	4173250	4188904	1	15971	128	9.66	5.54
NH-VPB-04	4175887	4175729	1	14573	106	10.04	6.09
NH-VPB-07	4173421	4186966	1	13474	119	9.03	5.65
CS-C02-062	4194684	4170957	1	12304	132	-9.19	2.97
3860J	4186237	4184450	1	11885	104	8.65	6.32
NH-VPB-08	4175423	4179369	1	11595	142	7.87	4.46
CS-C02-180	4194686	4170944	1	10946	124	-8.84	3.21
NH-C01-220	4178414	4179169	1	10806	107	8.76	4.95
3862D	4187048	4176699	1	10735	114	8.15	5.29
CS-VPB-03	4195804	4174867	1	10659	131	7.83	4.49
CS-VPB-08	4197803	4171355	1	9932	136	-8.20	2.40
CS-VPB-04	4199282	4172090	1	9807	148	-7.75	2.49
CS-VPB-02	4192237	4169947	1	9402	140	-7.73	2.81
PO-C02-053	4208139	4158382	1	9399	119	8.80	1.24
3830S	4177749	4182891	1	8533	94	9.07	2.95
CS-C05-160	4201495	4170334	1	8369	151	-7.00	2.53
NH-VPB-06	4169031	4186020	1	8241	75	4.77	9.40
CS-VPB-01	4193198	4171810	1	7506	127	-7.31	2.39
CS-VPB-07	4198053	4173548	1	7347	146	-6.78	2.09
CS-VPB-05	4201501	4170344	1	7076	145	-6.56	2.42
CS-C03-100	4198814	4173009	1	6950	140	-6.70	2.19
NH-VPB-02	4167573	4182305	1	6727	125	3.29	6.58
PO-VPB-05	4211695	4151123	1	6656	125	-6.35	3.62
NH-C05-320	4168865	4188433	1	5917	104	3.88	6.50
CS-01-105	4189486	4173107	1	3282	132	-3.93	3.09
3852F	4182477	4176104	1	2699	108	3.80	3.26
3948H	4209337	4152923	1	1183	181	-0.86	2.41
GNP-2	4200883	4171381	1	1037	14	-8.28	2.42
CS-VPB-09	4202634	4171934	1	789	151	-0.85	2.13
PO-VPB-02	4206260	4162306	1	681	126	-1.68	1.62
GNP-3	4200179	4170567	1	644	14	-6.18	2.90
GNP-4	4201890	4170496	1	613	14	-6.16	2.51

TABLE A3b

RESIDUALS FOR NEWLY INSTALLED WELLS - ONE DATA POINT

North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

Well Name	X-coord	Y-coord	Model Layer	Observed	Computed	Residual	Square
NH-C11-295	4165282.84	4186414.18	1	485.65	491.12	-5.47	29.95
NH-C09-310	4166724.26	4184988.29	1	484.78	488.01	-3.23	10.42
NH-C22-360	4168993.02	4190592.4	1	488.38	491.12	-2.74	7.52
NH-C19-290	4169092.48	4184287.43	1	485.73	486.17	-0.44	0.20
NH-C16-320	4171520.81	4188538.29	1	487.64	487.52	0.12	0.01
NH-C21-260	4171478.4	4182019.1	1	483.29	482.61	0.68	0.47
NH-C08-295	4173185.63	4185262.36	1	484.58	483.54	1.04	1.08
NH-C07-300	4172087.08	4184321.7	1	484.70	483.62	1.08	1.16
NH-C10-280	4172787.76	4182790.09	1	482.58	481.38	1.20	1.43
NH-C18-270	4170139.22	4183105.41	1	486.07	484.72	1.35	1.83
NH-C14-250	4174742.33	4181463.81	1	479.05	477.68	1.37	1.88
NH-C17-255	4177803.76	4180481.09	1	475.56	474.14	1.42	2.02
NH-C12-280	4176469.87	4182645.47	1	478.90	477.32	1.58	2.50
NH-C15-240	4174750.02	4180067.28	1	477.92	474.48	3.44	11.83
NH-C13-385	4166979.16	4187605.51	2	485.08	488.52	-3.44	11.82
NH-C22-460	4168984.03	4190592.08	2	488.20	491.02	-2.82	7.96
NH-C20-380	4169204.26	4186075.81	2	485.58	486.90	-1.32	1.74
NH-C19-360	4169092.48	4184287.43	2	485.07	486.12	-1.05	1.11
NH-C18-365	4170139.19	4183113.76	2	484.80	484.68	0.12	0.01
NH-C16-390	4171521.01	4188529.99	2	487.53	487.37	0.16	0.03
NH-C21-340	4171478.43	4182025.66	2	483.20	482.53	0.67	0.44
NH-C10-360	4172787.76	4182790.09	2	482.80	481.44	1.36	1.85
NH-C12-360	4176469.87	4182645.47	2	479.39	477.24	2.15	4.61
NH-C17-339	4177803.66	4180491.17	2	476.45	474.09	2.36	5.57
NH-C15-330	4174750.02	4180067.28	2	479.06	474.28	4.78	22.83
NH-C22-600	4168975.7	4190591.98	3	488.05	490.77	-2.72	7.40

Notes:
1. x,y coordinates are in NAD27 zone 5, LA County
2. The square of the residual for this well.

TABLE A4a

SUMMARY OF SENSITIVITY RUNS

North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

Location	Statistic					
Layer 1 Zone 68 NHOU	K	100 ft/d	120 ft/d	150 ft/d	187 ft/d	225 ft/d
	Mean	1.61	1.79	1.6	1.72	1.88
	Abs mean	7.82	7.89	7.79	7.93	7.99
	Std dev	9.67	9.74	9.64	9.81	9.86
	Min	-44.83	-44.93	-40.96	-45.22	-45.33
	Max	40.95	41.28	41.14	41.41	41.52
	norm std	0.043	0.043	0.043	0.044	0.044
Layer 1 Zone 70 NHOU South	K	110 ft/d	132 ft/d	165 ft/d	206 ft/d	248 ft/d
	Mean	1.78	1.63	1.6	1.73	1.73
	Abs mean	7.88	7.83	7.79	7.95	7.98
	Std dev	9.76	9.69	9.64	9.83	9.85
	Min	-44.76	-44.92	41.14	41.34	41.46
	Max	41.54	41	41.14	41.34	41.46
	norm std	0.043	0.043	0.043	0.044	0.043
Layer 1 Zone 78 GOU/N	K	165 ft/d	198 ft/d	248 ft/d	310 ft/d	372 ft/d
	Mean	1.13	1.38	1.6	2.2	2.59
	Abs mean	7.97	7.94	7.79	7.9	7.92
	Std dev	9.86	9.83	9.64	9.73	9.74
	Min	-45.54	-45.36	-40.96	-44.71	-44.35
	Max	40.89	41.29	41.14	41.54	42.19
	norm std	0.044	0.044	0.043	0.043	0.043
Layer 1 Zone 71 GOU/S LARN	K	110 ft/d	132 ft/d	165 ft/d	206 ft/d	248 ft/d
	Mean	0.99	1.26	1.6	2.49	Did
	Abs mean	8.1	8	7.79	7.94	not
	Std dev	9.91	9.86	9.64	9.75	converge
	Min	-45.34	-45.2	-40.96	-44.86	SP=73
	Max	40.95	41.29	41.14	41.95	
	norm std	0.044	0.044	0.043	0.043	
Layer 1 Zone 72 Burbank South	K	110 ft/d	132 ft/d	165 ft/d	206 ft/d	248 ft/d
	Mean	1.76	1.65	1.6	1.84	1.87
	Abs mean	7.8	7.82	7.79	8.02	8.12
	Std dev	9.67	9.68	9.64	9.88	9.99
	Min	-44.36	-44.65	-40.96	-45.46	-45.87
	Max	41.16	40.87	41.14	41.49	41.9
	norm std	0.043	0.043	0.043	0.044	0.045

TABLE A4a

SUMMARY OF SENSITIVITY RUNS

North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

Location	Statistic					
Layer 2 Zone 81 NHOU	K	225 ft/d	270 ft/d	338 ft/d	423 ft/d	507 ft/d
	Mean	1.69	1.73	1.6	1.69	1.73
	Abs mean	7.97	7.89	7.79	7.91	7.95
	Std dev	9.73	9.75	9.64	9.27	9.81
	Min	-44.84	-44.94	-40.96	-45.14	-45.32
	Max	40.88	41.26	41.14	41.1	41.32
	norm std	0.043	0.043	0.043	0.044	0.044
Layer 2 Zone 73 Glendale North	K	125 ft/d	150 ft/d	188 ft/d	235 ft/d	282 ft/d
	Mean	1.86	1.67	1.6	1.78	1.85
	Abs mean	7.92	7.88	7.79	7.96	7.99
	Std dev	9.79	9.76	9.64	9.83	9.85
	Min	-44.84	-44.94	-40.96	-45.14	-45.17
	Max	41.47	41.31	41.14	41.55	41.7
	norm std	0.044	0.043	0.043	0.044	0.044
Layer 2 Zone 77	K	137 ft/d	165 ft/d	206 ft/d	258 ft/d	309 ft/d
	Mean	1.76	1.77	1.6	1.78	1.94
	Abs mean	7.86	7.89	7.79	7.97	8.06
	Std dev	9.77	9.76	9.64	9.83	9.92
	Min	-44.59	-44.8	-40.96	-45.37	-45.63
	Max	41.44	41.33	41.14	41.54	41.71
	norm std	0.044	0.043	0.043	0.044	0.044
Layer 2 Zone 82	K	303 ft/d	363 ft/d	454 ft/d	568 ft/d	681 ft/d
	Mean	0.55	0.91	1.6	2.57	3.58
	Abs mean	8	7.92	7.79	7.94	8.12
	Std dev	9.9	9.83	9.64	9.76	9.87
	Min	-44.01	-44.54	-40.96	-45.48	-45.67
	Max	40.47	40.63	41.14	42	43.06
	norm std	0.044	0.044	0.043	0.043	0.044
Layer 3 Zone 74	K	125 ft/d	150 ft/d	188 ft/d	235 ft/d	282 ft/d
	Mean	2.07	1.99	1.6	1.44	1.45
	Abs mean	8.01	7.98	7.79	7.85	7.83
	Std dev	9.89	9.85	9.64	9.72	9.66
	Min	-44.68	-44.83	-40.96	-45.23	-45.46
	Max	42.22	41.83	41.14	40.57	39.92
	norm std	0.044	0.044	0.043	0.043	0.043

TABLE A4a

SUMMARY OF SENSITIVITY RUNS

North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

Location	Statistic					
Layer 3 Zone 69	K	100 ft/d	120 ft/d	150 ft/d	187 ft/d	225 ft/d
	Mean	1.88	1.89	1.6	1.58	1.71
	Abs mean	7.81	7.87	7.79	7.97	8.08
	Std dev	9.67	9.72	9.64	9.85	9.95
	Min	-44.57	-44.83	-40.96	-45.35	-45.56
	Max	41.21	41.47	41.14	41.43	41.47
	norm std	0.043	0.043	0.043	0.044	0.044
Layer 3 Zone 66	K	83 ft/d	99 ft/d	124 ft/d	155 ft/d	186 ft/d
	Mean	1.67	1.95	1.6	2.09	2
	Abs mean	7.73	7.85	7.79	7.96	7.98
	Std dev	9.57	9.69	9.64	9.76	9.78
	Min	-40.51	-40.71	-40.96	-41.24	-41.49
	Max	40.84	41.39	41.14	41.41	41.5
	norm std	0.043	0.043	0.043	0.043	0.044
Layer 4 Zone 54	K	35 ft/d	42 ft/d	52.5 ft/d	66 ft/d	79 ft/d
	Mean	2.02	1.94	1.6	1.86	1.41
	Abs mean	7.86	7.86	7.79	7.89	7.78
	Std dev	9.69	9.7	9.64	9.69	9.59
	Min	-40.06	-40.73	-40.96	-41.15	-41.36
	Max	41.52	41.32	41.14	40.89	40.12
	norm std	0.043	0.043	0.043	0.043	0.043
Layer 4 Zone 67	K	83 ft/d	99 ft/d	124 ft/d	155 ft/d	186 ft/d
	Mean	1.58	1.77	1.6	2.13	2.27
	Abs mean	7.64	7.76	7.79	8.01	8.15
	Std dev	9.49	9.6	9.64	9.81	9.96
	Min	-40.19	-40.52	-40.96	-41.44	-41.79
	Max	40.7	41.03	41.14	41.38	42.2
	norm std	0.042	0.043	0.043	0.044	0.044
Layer 4 Zone 52	K	33 ft/d	40 ft/d	50 ft/d	62 ft/d	74 ft/d
	Mean	1.57	2.05	1.6	1.93	1.97
	Abs mean	7.74	7.9	7.79	7.9	7.93
	Std dev	9.59	9.71	9.64	9.73	9.76
	Min	-40.8	-40.88	-40.96	-41.02	-41.1
	Max	40.99	41.56	41.14	41.34	41.55
	norm std	0.043	0.043	0.043	0.043	0.043

TABLE A4a

SUMMARY OF SENSITIVITY RUNS

North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

Location	Statistic					
All Layer 1	K	0.667*K	0.80*K	1.0*K	1.25*K	1.50*K
	Mean	4.48	Did	1.6	0.33	-0.41
	Abs mean	9.24	not	7.79	7.27	6.97
	Std dev	10.85	converge	9.64	9.11	8.72
	Min	-39.53	SP=73	-40.96	-41.73	-42.55
	Max	46.9		41.14	38.26	35.76
	norm std	0.048		0.043	0.041	0.039
All Layer 2	K	0.667*K	0.80*K	1.0*K	1.25*K	1.50*K
	Mean	Did	Did	1.6	0.72	-0.55
	Abs mean	not	not	7.79	7.26	6.89
	Std dev	converge	converge	9.64	9.09	8.62
	Min	SP=73	SP=73	-40.96	-42.35	-43.57
	Max			41.14	38.24	34.89
	norm std			0.043	0.04	0.038
All Layer 3	K	0.667*K	0.80*K	1.0*K	1.25*K	1.50*K
	Mean	Did	3.12	1.6	0.85	-0.07
	Abs mean	not	8.01	7.79	7.87	7.95
	Std dev	converge	9.75	9.64	9.71	9.76
	Min	SP=73	-39.54	-40.96	-42.63	-44.17
	Max		43.03	41.14	39.62	37.97
	norm std		0.043	0.043	0.043	0.044
All Layer 4	K	0.667*K	0.80*K	1.0*K	1.25*K	1.50*K
	Mean	2.12	2.01	1.6	1.81	Did
	Abs mean	7.57	7.67	7.79	8.12	not
	Std dev	9.42	9.51	9.64	9.93	converge
	Min	-39.15	-39.88	-40.96	-42.13	SP=73
	Max	41.76	41.51	41.14	41.25	
	norm std	0.042	0.042	0.043	0.044	
Recharge (topmost active node)	Recharge	0.833*Rech	0.909*Rech	1xRech	1.1*Rech	1.2*Rech
	Mean	13.4	8.14	1.6	Did	-10.18
	Abs mean	14.55	10.52	7.79	not	11.93
	Std dev	12.69	11.04	9.64	converge	10
	Min	-39.93	-40.34	-40.96	SP=59	-48.67
	Max	54.76	48.46	41.14		26.61
	norm std	0.057	0.049	0.043		0.045

TABLE A4a

SUMMARY OF SENSITIVITY RUNS

North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

Location	Statistic					
Specific Yield Layer 1 Zone 6	Sy	0.113	0.136	0.17	0.213	0.255
	Mean	3.3	3.05	1.6	0.86	0.07
	Abs mean	8.38	8.24	7.79	7.61	7.48
	Std dev	10.49	10.18	9.64	9.35	9.18
	Min	-40.55	-40.68	-40.96	-41.19	-41.49
	Max	46.36	44.71	41.14	38.07	35.52
	norm std	0.047	0.045	0.043	0.042	0.041
Specific Yield Layer 1 Zone 7	Sy	0.12	0.144	0.18	0.225	0.27
	Mean	2.04	2.07	1.6	1.73	1.85
	Abs mean	7.89	7.92	7.79	7.82	7.88
	Std dev	9.71	9.75	9.64	9.63	9.68
	Min	-39.33	-40.02	-40.96	-41.95	-42.81
	Max	41.59	41.76	41.14	40.79	40.9
	norm std	0.043	0.043	0.043	0.043	0.043

Abbreviations:

Abs mean = average of the absolute value of each residual
Max = maximum of the residuals
Mean = arithmetic average
Min = minimum of the residual
norm std = the normalized standard deviation, i.e., std dev/range of observed water levels
residual = the observed minus the computed head
Std dev = standard devaition of the residuals
Sy = specific yield

TABLE A4b

OTHER SENSITIVITY RUNS

North Hollywood Operable Unit

Second Interim Remedy

Groundater Remediation Design

Residual measure	Calibrated 116 SP	Three K-Zone Model	With Verdugo Fault	With Data Base Screen Intervals
Mean	1.6	0.37	1.9	1.96
Absolute mean	7.79	8.2	7.88	7.84
Standard deviation	9.64	10.64	9.7	9.69
Sum of squares	984,000	1,120,000	1,010,000	1,010,000
Maxium	-40.96	-44.33	-40.83	-40.91
Minimum	41.14	44.37	41.38	41.48
Range	224.39	224.39	224.39	224.39
Normalized std dev	0.043	0.047	0.043	0.043
Number targets	10,294	10,294	10,294	10,294

TABLE A5a

EXTRACTION WELL RATES FOR MAXIMUM (DRY) CONDITIONS

North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

Stress Per	Time Step	Layer	NHE-1	NHE-2	NHE-3	NHE-4	NHE-5	NHE-6	NHE-7	NHE-8	Total-ft3/d	Total(gpm)	Total-SP-gpm
1	1	1	0	14631	27722	17711	5390	0	28877	36385	130716	679	
		2						31380			31380	163	842
1	5	1	0	14631	27722	17711	5390	0	28877	36385	130716	679	
		2						31380			31380	163	842
2	5	1	0	14631	1226	17711	1850	0	28877	36385	100680	523	
		2						31380			31380	163	686
3	5	1	0	1112	1171	0	0	0	14570	36385	53238	277	
		2						31380			31380	163	440
4	5	1	0	0	0	0	0	0	0	36385	36385	189	
		2						31380			31380	163	352
5	5	1	0	0	0	0	0	0	0	0	0	0	
		2						31380			31380	163	163
6	5	1	0	0	0	0	0	0	0	0	0	0	
		2						31380			31380	163	163
7	5	1	0	0	0	0	0	0	0	0	0	0	
		2						31380			31380	163	163
8	5	1	0	0	0	0	0	0	0	0	0	0	
		2						31380			31380	163	163
9	5	1	0	0	0	0	0	0	0	0	0	0	
		2						31380			31380	163	163
10	5	1	0	0	0	0	0	0	0	0	0	0	
		2						31380			31380	163	163
11	5	1	0	0	0	0	0	0	0	0	0	0	
		2						31380			31380	163	163

Well has lost its initial pumping rate

TABLE A5b

EXTRACTION WELL RATES FOR ALTERNATIVE 2-4 MAXIMUM (DRY)
North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

Stress Per	Time Step	Layer	New001	New002	New003	NHE-1	NHE-2	NHE-3	NHE-4	NHE-5	NHE-6	NHE-7	NHE-8	Total -ft3/d	Total - gpm	Total-SP-gpm
		1	0	0	0	0	0	48122	0	0	0	48122	48122	144366	750	
		2	67380	67380	67380	48122	48122		0	0	48122			346506	1800	
1	1	3							48122	48122				96244	500	3050
		1	0	0	0	0	0	26258	0	0	0	48122	48122	122502	636	
		2	67380	67380	67380	48122	48122		0	0	48122			346506	1800	
1	5	3							48122	48122				96244	500	2936
		1	0	0	0	0	0	0	0	0	0	48122	48122	96244	500	
		2	67380	67380	67380	48122	48122		0	0	48122			346506	1800	
2	5	3							48122	48122				96244	500	2800
		1	0	0	0	0	0	0	0	0	0	0	48122	48122	250	
		2	67380	67380	67380	48122	48122		0	0	48122			346506	1800	
3	5	3							48122	48122				96244	500	2550
		1						0				0	11392	11392	59	
		2	67380	67380	67380	48122	48122		0	0	48122			346506	1800	
4	5	3							48122	48122				96244	500	2359
		1						0				0	0	0	0	
		2	67380	67380	67380	48122	48122		0	0	48122			346506	1800	
5	5	3							48122	48122				96244	500	2300
		1						0				0	0	0	0	
		2	67380	67380	67380	48122	48122		0	0	48122			346506	1800	
6	5	3							48122	48122				96244	500	2300
		1						0				0	0	0	0	
		2	67380	67380	67380	48122	48122		0	0	48122			346506	1800	
7	5	3							48122	48122				96244	500	2300
		1						0				0	0	0	0	
		2	67380	67380	67380	48122	48122		0	0	48122			346506	1800	
8	5	3							48122	48122				96244	500	2300
		1						0				0	0	0	0	
		2	67380	67380	67380	48122	48122		0	0	48122			346506	1800	
9	5	3							48122	48122				96244	500	2300
		1						0				0	0	0	0	
		2	67380	67380	67380	48122	48122		0	0	48122			346506	1800	
10	5	3							48122	48122				96244	500	2300
		1						0				0	0	0	0	
		2	67380	67380	67380	48122	48122		0	0	48122			346506	1800	
11	5	3							48122	48122				96244	500	2300

Well has lost its initial pumping rate

TABLE A5c

EXTRACTION WELL RATES FOR NFA AVERAGE CONDITIONS

North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

Stress Per	Time Step	Layer	NHE-1	NHE-2	NHE-3	NHE-4	NHE-5	NHE-6	NHE-7	NHE-8	Total-ft3/d	Total(gpm)	Total-SP-gpm
1	1	1	0	14631	27722	17711	5390	0	28877	36385	130716	679	
		2						31380			31380	163	842
1	5	1	0	14631	27722	17711	5390	0	28877	36385	130716	679	
		2						31380			31380	163	842
2	5	1	0	14631	27722	17711	5390	0	28877	36385	130716	679	
		2						31380			31380	163	842
3	5	1	0	14631	27722	17711	5390	0	28877	36385	130716	679	
		2						31380			31380	163	842
4	5	1	0	14631	27722	17711	5390	0	28877	36385	130716	679	
		2						31380			31380	163	842
5	5	1	0	14631	27722	17711	5390	0	28877	36385	130716	679	
		2						31380			31380	163	842
6	5	1	0	14631	27036	17711	5390	0	28877	36385	130030	675	
		2						31380			31380	163	838
7	5	1	0	14631	12468	17711	5088	0	28877	36385	115160	598	
		2						31380			31380	163	761
8	5	1	0	14631	279	17711	72	0	28877	36385	97955	509	
		2						31380			31380	163	672
9	5	1	0	14631	0	17711	0	0	28877	36385	97604	507	
		2						31380			31380	163	670
10	5	1	0	14631	0	17711	0	0	28877	36385	97604	507	
		2						31380			31380	163	670
11	5	1	0	14631	0	17711	0	0	28877	36385	97604	507	
		2						31380			31380	163	670

Well has lost its initial pumping rate

TABLE A5d

EXTRACTION WELL RATES FOR NFA MAXIMUM (DRY) CONDITIONS

North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

Stress Per	Time Step	Layer	NHE-1	NHE-2	NHE-3	NHE-4	NHE-5	NHE-6	NHE-7	NHE-8	Total-ft3/d	Total(gpm)	Total-SP-gpm
1	1	1	0	14631	27722	17711	5390	0	28877	36385	130716	679	
		2						31380			31380	163	842
1	5	1	0	14631	27722	17711	5390	0	28877	36385	130716	679	
		2						31380			31380	163	842
2	5	1	0	14631	1226	17711	1850	0	28877	36385	100680	523	
		2						31380			31380	163	686
3	5	1	0	1112	1171	0	0	0	14570	36385	53238	277	
		2						31380			31380	163	440
4	5	1	0	0	0	0	0	0	0	36385	36385	189	
		2						31380			31380	163	352
5	5	1	0	0	0	0	0	0	0	0	0	0	
		2						31380			31380	163	163
6	5	1	0	0	0	0	0	0	0	0	0	0	
		2						31380			31380	163	163
7	5	1	0	0	0	0	0	0	0	0	0	0	
		2						31380			31380	163	163
8	5	1	0	0	0	0	0	0	0	0	0	0	
		2						31380			31380	163	163
9	5	1	0	0	0	0	0	0	0	0	0	0	
		2						31380			31380	163	163
10	5	1	0	0	0	0	0	0	0	0	0	0	
		2						31380			31380	163	163
11	5	1	0	0	0	0	0	0	0	0	0	0	
		2						31380			31380	163	163

Well has lost its initial pumping rate

TABLE A6a

WATER BALANCE COMPONENTS

North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

Year	IN				OUT				
	Storage	**Well**	**Recharge**	**River**	**Storage**	**Well**	**Const Head**	**GHB**	**River**
1	2225859	3697319	6845528	1317238	456640	12001043	4490	58479	1567216
2	1984199	3697319	6845528	1308513	68896	12100390	4398	58507	1619587
3	1917861	3697319	6845528	1312749	12279	12100207	4368	58516	1610089
4	1850567	3697319	6845528	1325885	2432	12093168	4356	58517	1568700
5	1750376	3697319	6845528	1339679	346	12066588	4350	58516	1516757
6	1664404	3697319	6845528	1355869	33	12051845	4346	58514	1464118
7	1598926	3697319	6845528	1368678	0	12051805	4343	58511	1410044
8	1527244	3697319	6845528	3697319	0	12049472	4340	58508	1364898
9	1452598	3697319	6845528	1420023	0	12037206	4336	58506	1332670
10	1372579	3697319	6845528	1443983	0	12011603	4333	58503	1300959
11	1286435	3697319	6845528	1460554	0	11975404	4330	58500	1267783

Units are cubic feet per day

TABLE A6b

WATER BALANCE COMPONENTS
ALTERNATIVES 2-4 MAXIMUM YIELD (DRY)
North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

Year	IN				OUT				
	Storage	Well	Recharge	River	Storage	Well	Const Head	GHB	River
1	8538131	1298221	6845528	1331779	138527	16297069	4490	58479	1539832
2	3386614	2045389	6845528	1351134	10002	12051953	4398	58506	1516498
3	9137069	415571	6845528	1386316	356	16319268	4367	58512	1421393
4	2801674	2237280	6845528	1463911	92364	11880370	4353	58508	1314099
5	7279868	1780153	6845528	1492483	30405	16061968	4346	58504	1234322
6	6692209	1846462	6845528	1569945	9771	15790401	4335	58493	1103079
7	912501	7377777	6845528	1645846	4203106	11440173	4325	58483	1049667
8	5335235	2855289	6845528	1688830	20922	15630321	4314	58472	1012597
9	5305616	2630840	6845528	1727420	29	15475258	4303	58462	976922
10	443525	8339735	6845528	1751380	5183659	11192227	4291	58452	937022
11	5308119	2480810	6845528	1761388	1070	15432404	4278	58442	902799

Units are cubic feet per day

TABLE A6c

WATER BALANCE COMPONENTS
NFA AVERAGE CONDITIONS

North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

Year	IN				OUT				
	Storage	Well	Recharge	River	Storage	Well	Const Head	GHB	River
1	1866372	3697319	6845528	1316091	518321	11576025	4488	58479	1571450
2	1600038	3697319	6845528	1303511	87604	11675372	4398	58508	1633865
3	1528973	3697319	6845528	1308009	17228	11675198	4369	58516	1637725
4	1480419	3697319	6845528	1315394	4201	11675091	4357	58518	1607070
5	1424450	3697319	6845528	1328061	747	11675019	4351	58517	1567259
6	1366829	3697319	6845528	1340054	101	11674283	4348	58516	1524039
7	1297086	3697319	6845528	1352366	3	11659375	4345	58514	1481162
8	1222260	3697319	6845528	1364599	0	11642139	4342	58512	1439501
9	1171567	3697319	6845528	1374268	0	11641762	4340	58510	1398195
10	1117181	3697319	6845528	1389900	0	11641741	4337	58508	1364654
11	1066486	3697319	6845528	1412965	0	11635113	4334	58506	1340837

Units are cubic feet per day

TABLE A6d

WATER BALANCE COMPONENTS
NFA MAXIMUM YIELD (DRY)
North Hollywood Operable Unit
Second Interim Remedy
Groundater Remediation Design

Year	IN				OUT				
	Storage	Well	Recharge	River	Storage	Well	Const Head	GHB	River
1	8128666	1298221	6845528	1330779	148522	15893981	4490	58479	1543341
2	2998784	2045389	6845528	1349458	11875	11645020	4398	58506	1529480
3	8774298	415571	6845528	1382957	383	15913033	4367	58512	1445276
4	2530546	2237280	6845528	1451136	132550	11533638	4354	58510	1336306
5	6844482	1780153	6845528	1495063	25244	15656670	4345	58504	1234296
6	6403527	1846462	6845528	1549498	9780	15457482	4336	58496	1129035
7	802731	7377777	6845528	1619182	4395128	11118485	4327	58487	1066184
8	5079829	2855289	6845528	1662468	20973	15327863	4317	58477	1032759
9	5050464	2630840	6845528	1701571	29	15172382	4307	58468	1002009
10	369930	8339735	6845528	1734555	5349209	10900761	4296	58460	968834
11	5076439	2480810	6845528	1747378	1102	15140722	4286	58451	943053

Units are cubic feet per day

FIGURES

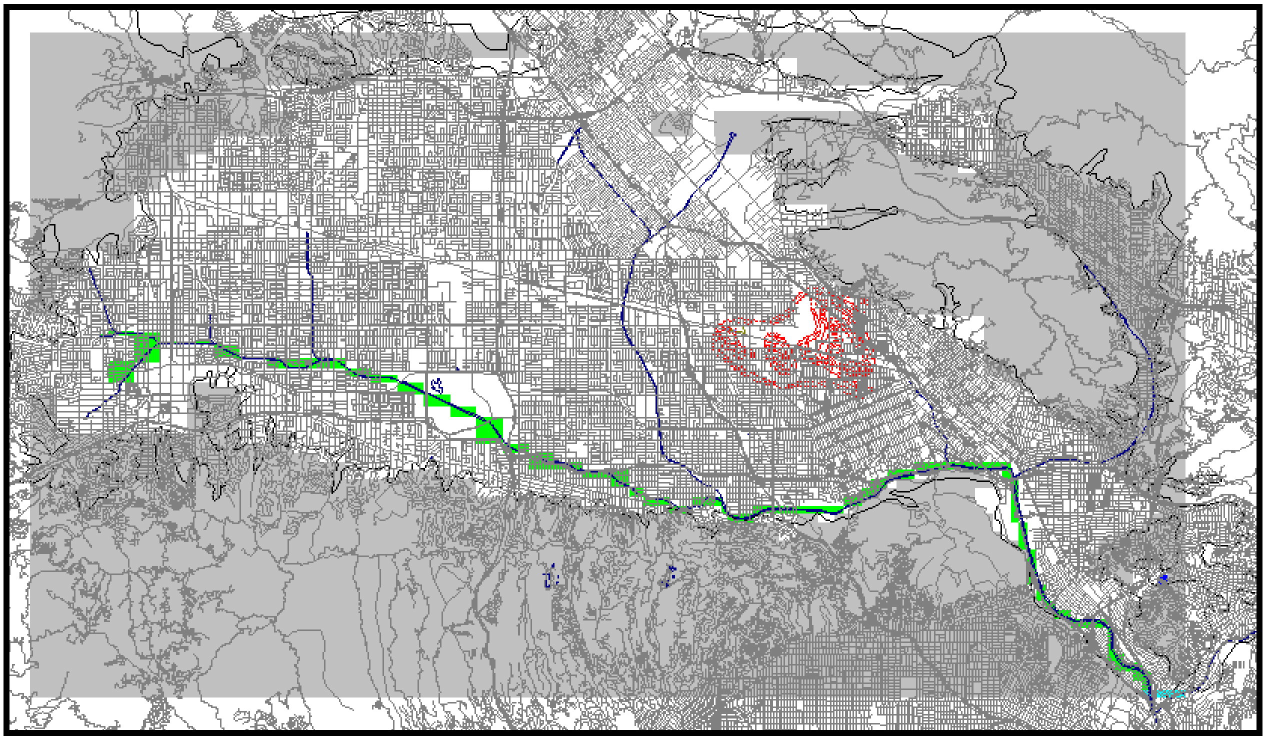


Figure A1a: The model domain (model layer 1) showing boundary conditions and other features. The gray indicates inactive areas in the model outlining the surrounding mountains and defining the active area of the model as the San Fernando Basin. The green indicates the Los Angeles River. The red dots in the central east portion of the basin are particles seeded to represent the interpreted extents of the VOC and chromium plumes as represented in the FFS. In the lower right corner, the light blue nodes are general head boundaries representing the exit of the groundwater flow through the Los Angeles River Narrows. A single dark blue node above the general head boundaries is a constant head node associated with the Eagle Rock sub-basin. For clarity, the road base map will not be included in succeeding figures.

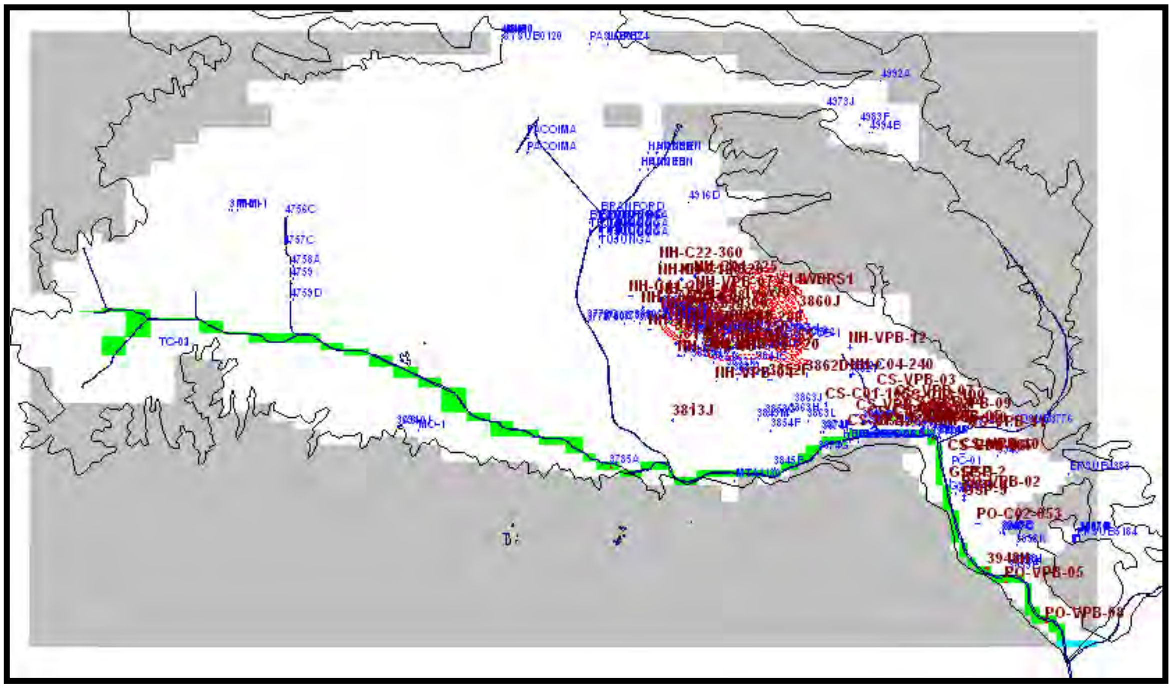


Figure A1b: As in Figure A1a, but without the base map of roads in the SFB. Also shown here in blue are the analytical wells representing spreading grounds and production and extraction wells in model layer 1, and in red, locations of target water level wells.

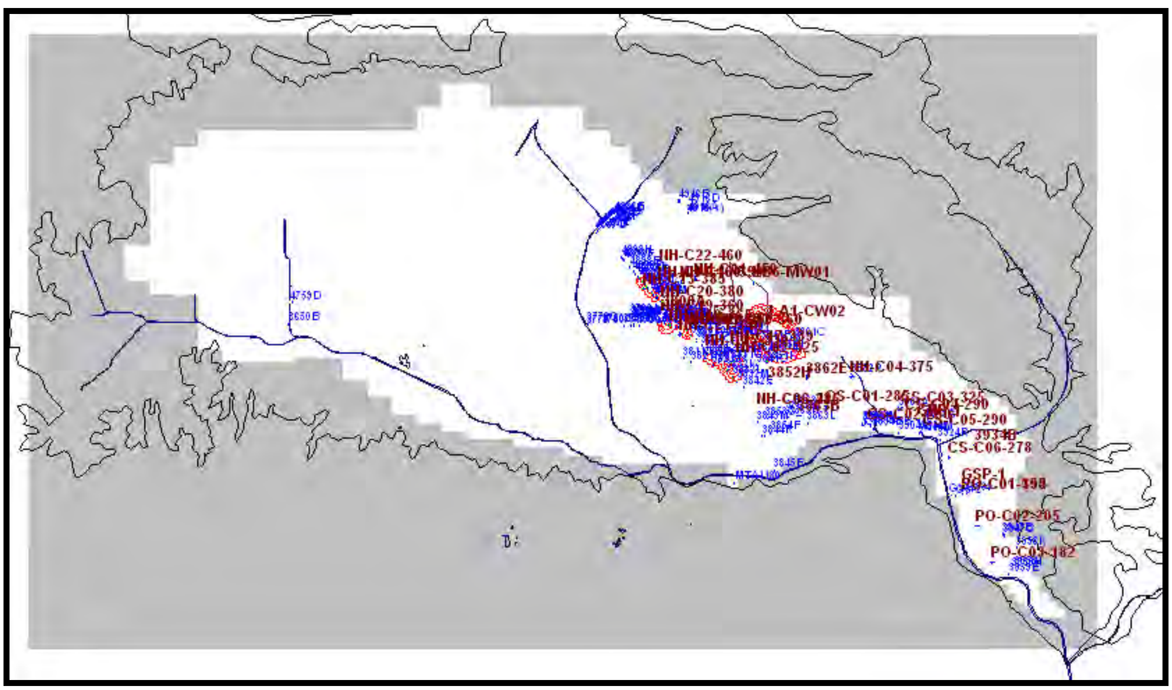


Figure A2: Model domain (white area) in model layer 2. The valley narrows with depth. Blue labels indicate wells penetrating this layer. Red dots are particles outlining the interpreted extent of plumes. The LA River is shown for reference only here and in the next two figures.

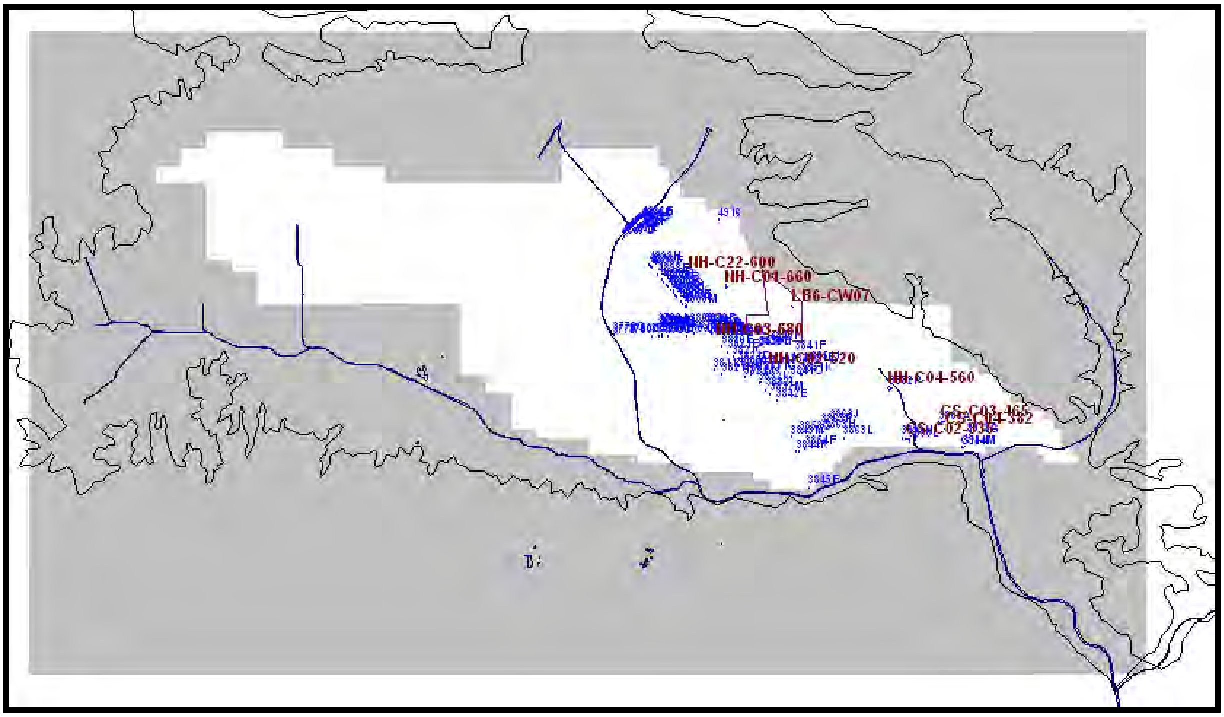


Figure A3: Model domain (white area) in model layer 3, again smaller with depth.

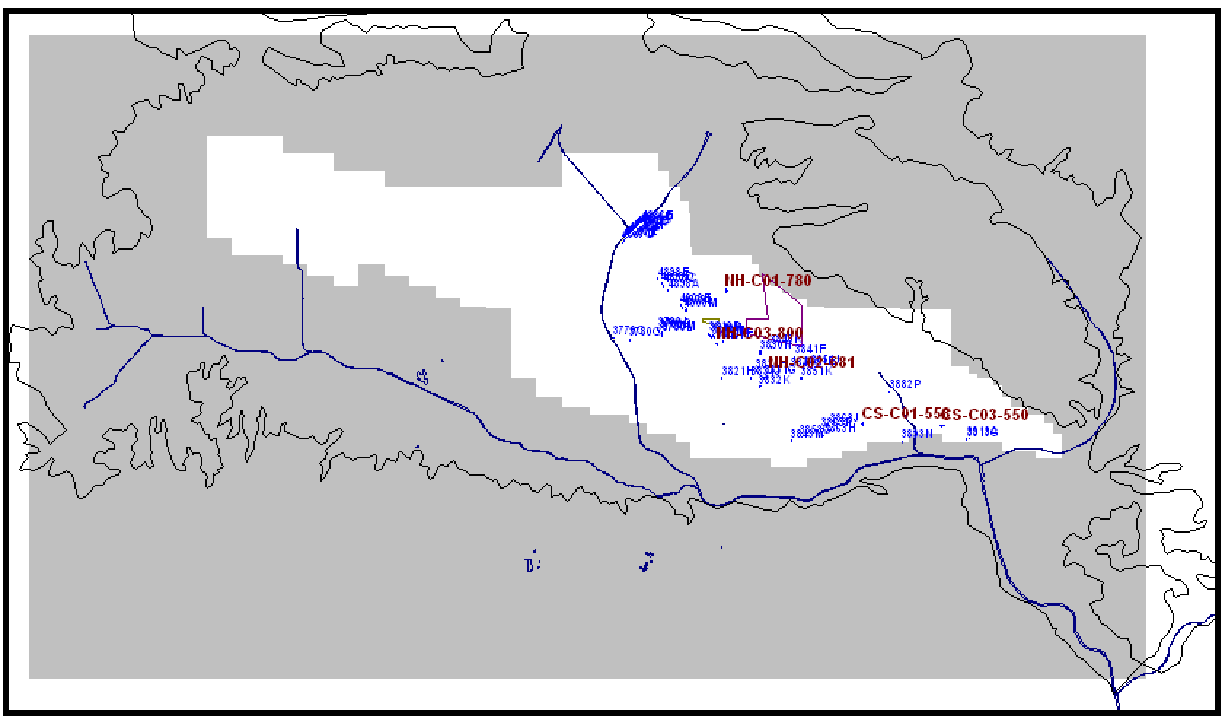


Figure A4: Model domain (white area) in model layer 4.

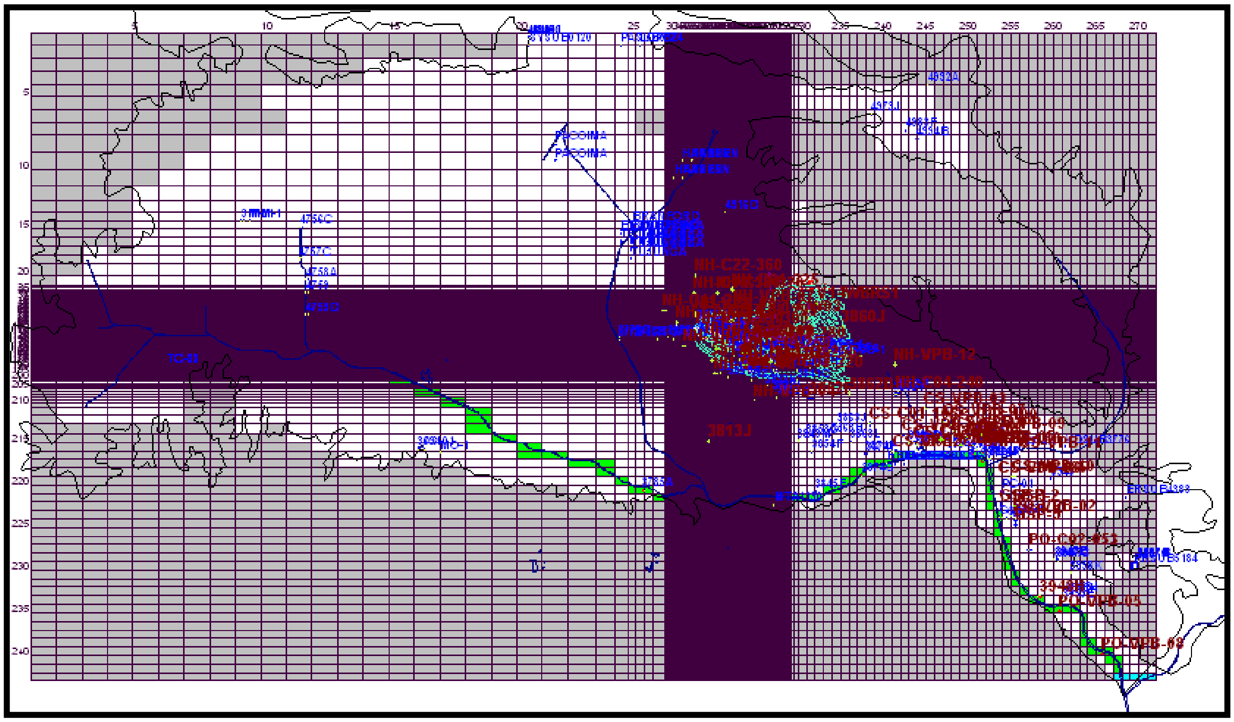


Figure A5: Model layer 1 with variable model grid overlain. The grid is most finely discretized in the NHOU area.

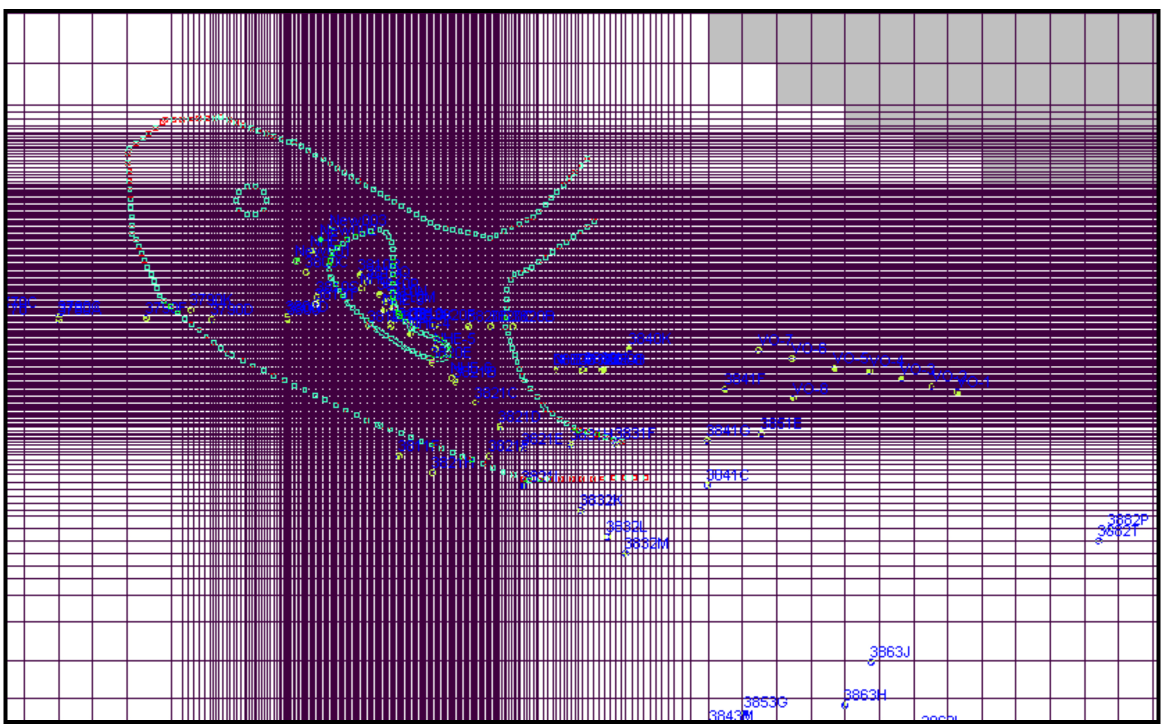


Figure A6: A closer view of the NHOU extraction system area and closely spaced grid. The particles outlining the interpreted plumes appear green in this view.

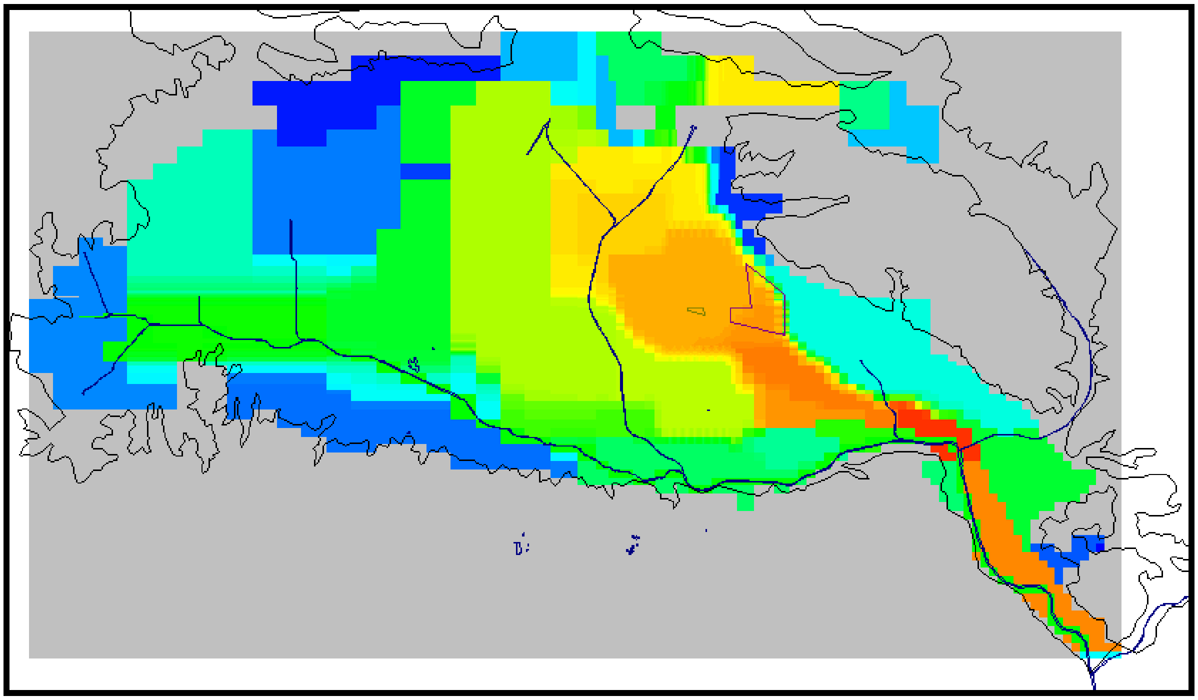


Figure A7: Zones of hydraulic conductivity assigned in Model Layer 1. Zones of higher hydraulic conductivity are oriented NW-SE through the NHOU and BOU areas and south through the LA River Narrows.

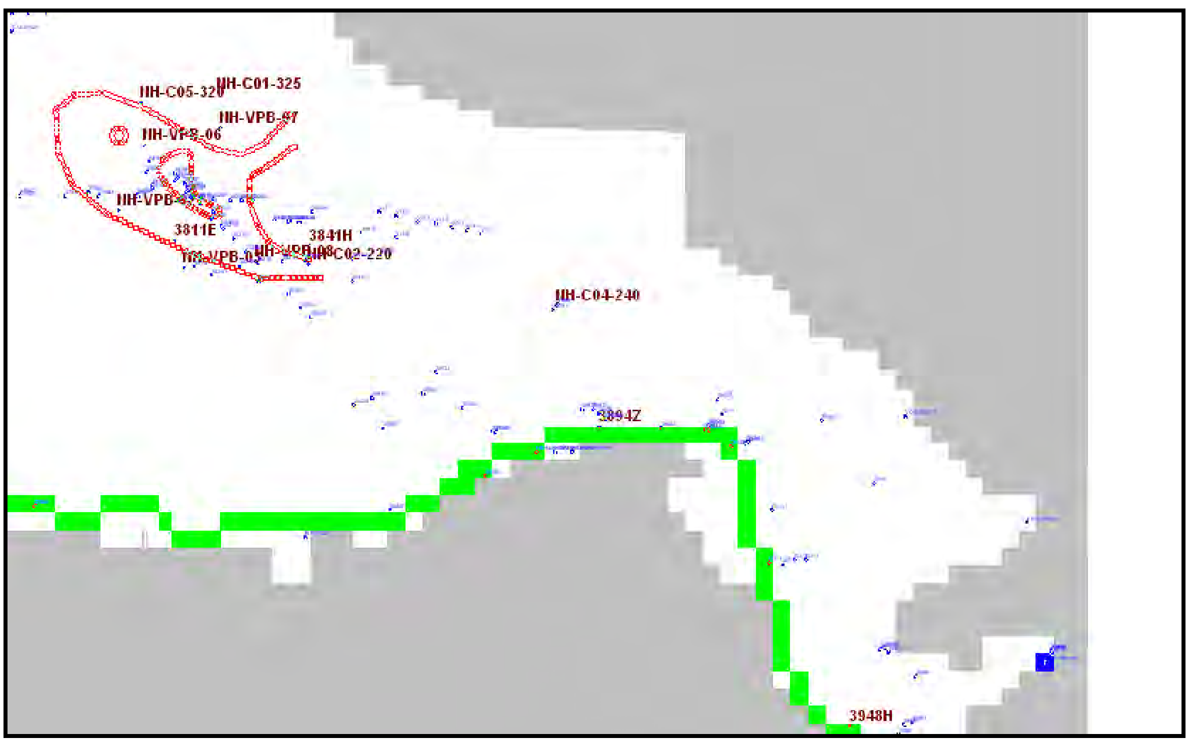


Figure A8: Location of target water level monitoring well locations (red labels) in model layer 1 used for model goodness-of-fit NHOU residuals analysis (small target data set).

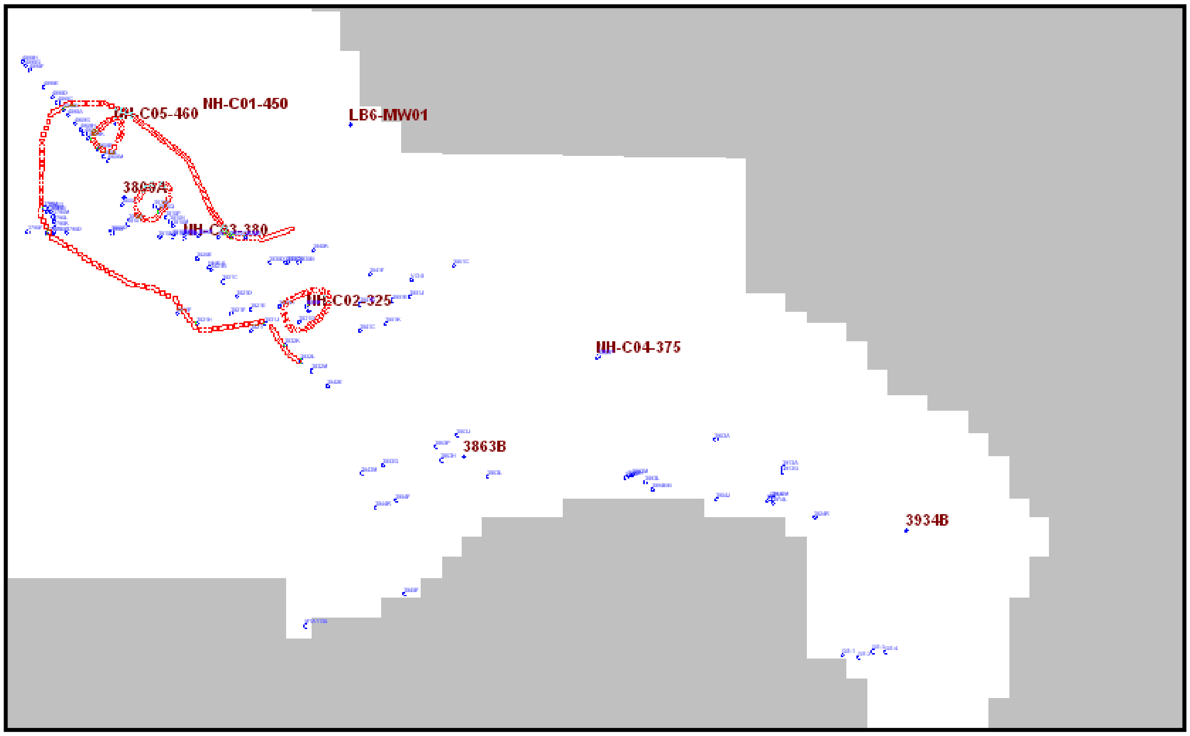


Figure A9: Location of target water level monitoring well locations in model layer 2 used for model goodness-of-fit NHOU residuals analysis (small target data set).

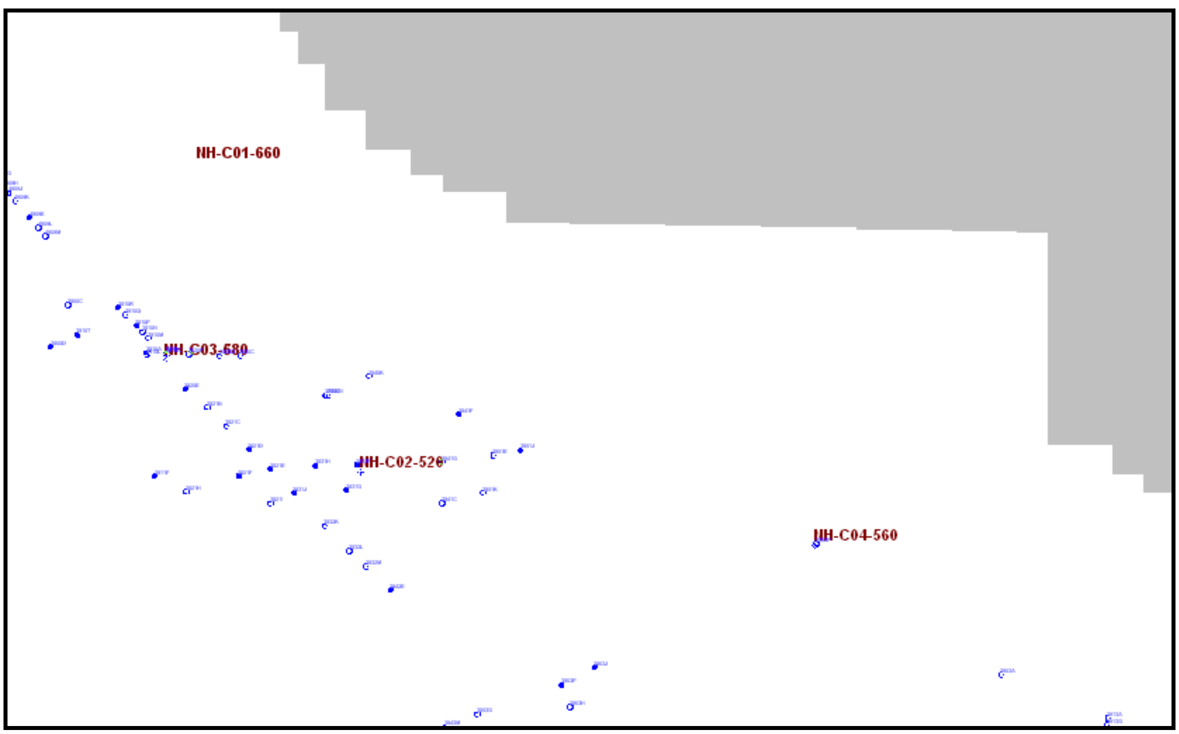


Figure A10: Location of target water level monitoring well locations in model layer 3 used for model goodness-of-fit NHOU residuals analysis (small target data set).

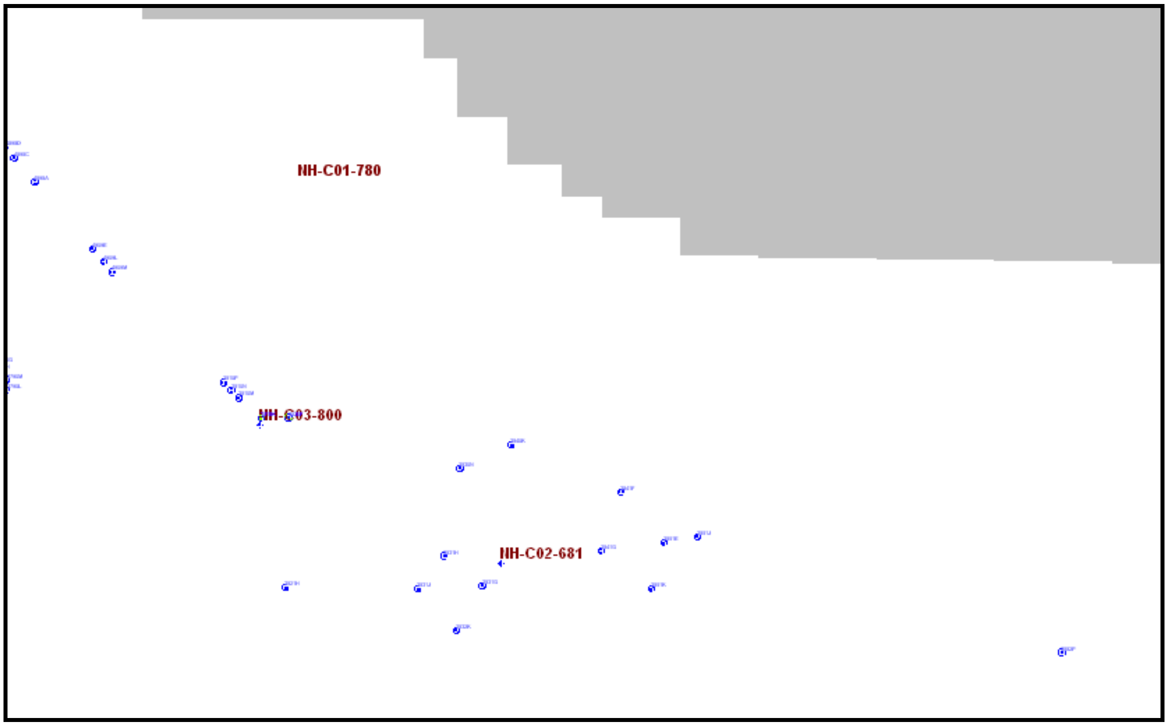


Figure A11: Location of target water level monitoring well locations in model layer 4 used for model goodness-of-fit NHOU residuals analysis (small target data set).

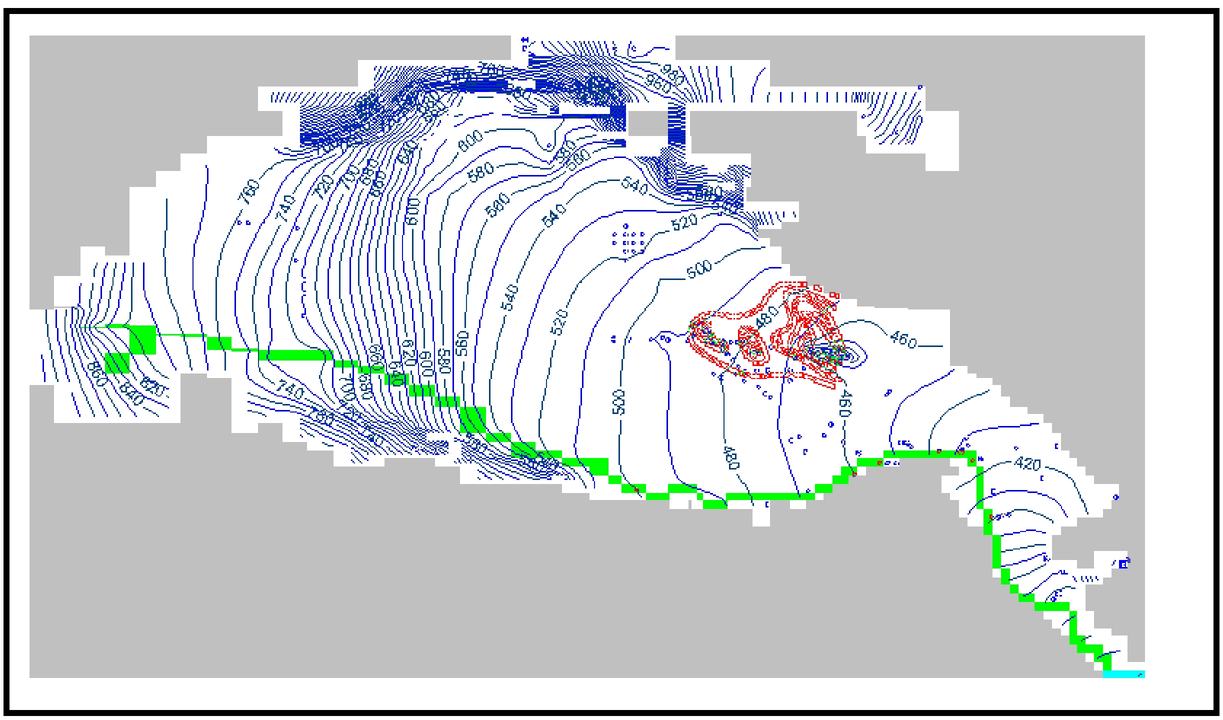


Figure A12: Head distribution in model layer 1, FFS calibrated model, end of stress period 100.

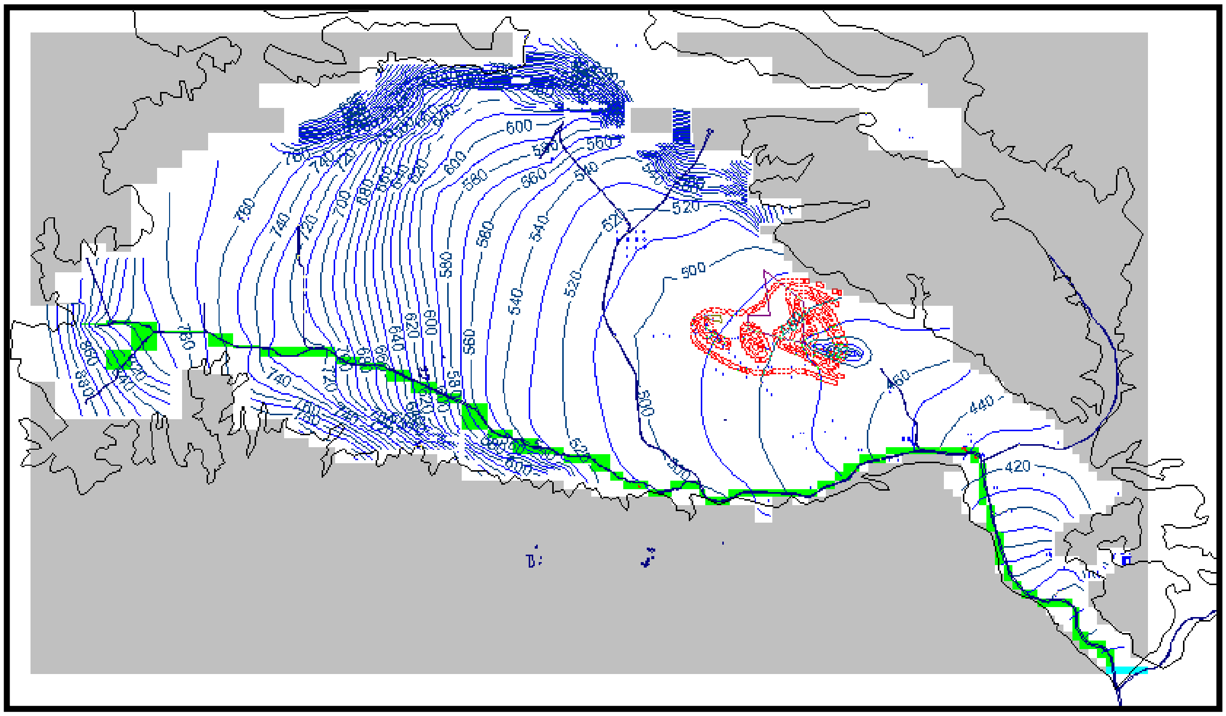


Figure A13: Head distribution in model layer 1, FFS model extended, end of stress period 116.

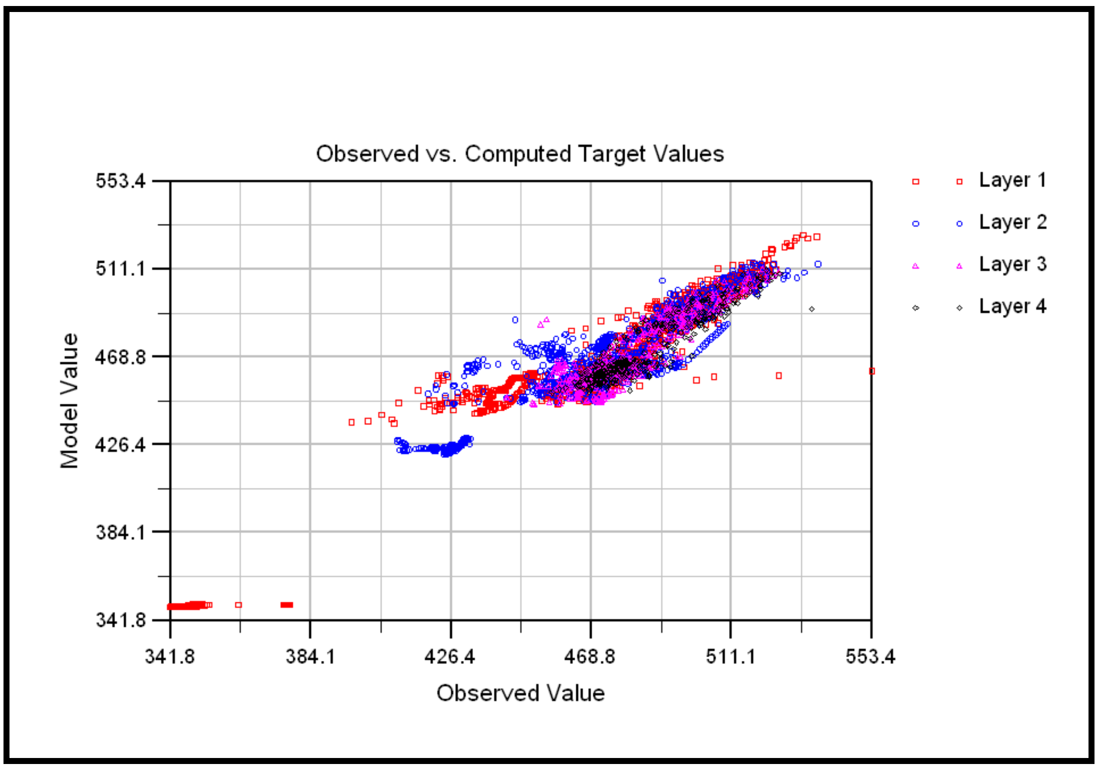


Figure A14a: Plot of calibrated model computed versus observed. NHOU target data set only FFS calibrated model. In a perfect fit, all values would lie on a 1:1 slope line.

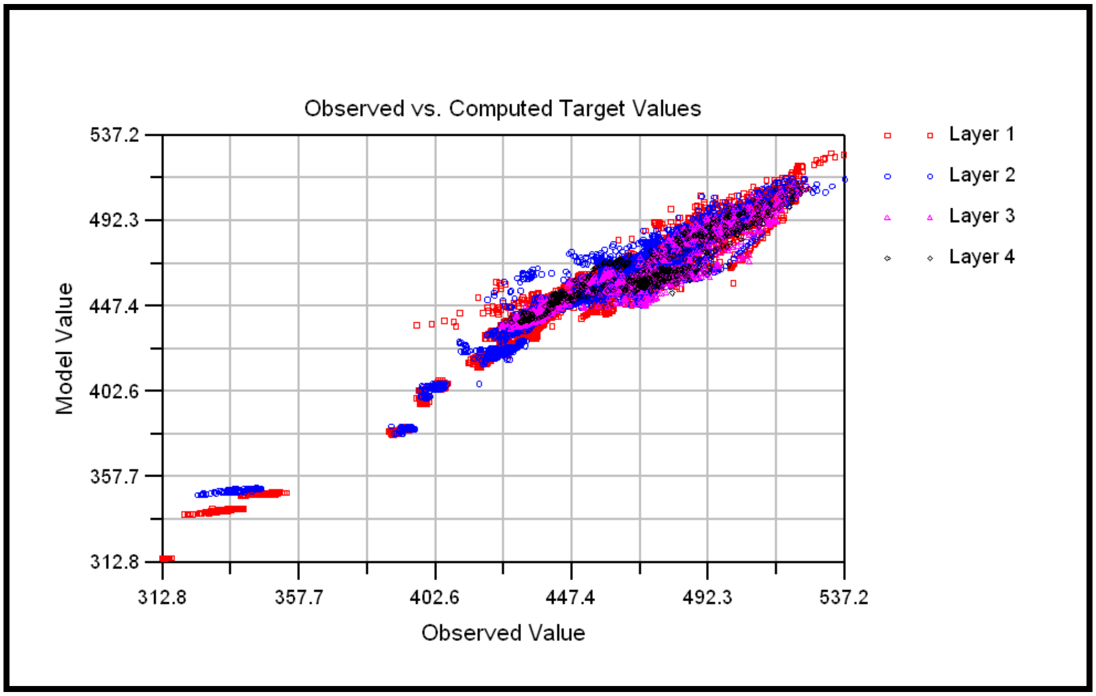


Figure A14b: Plot of calibrated model computed versus observed. FFS model with extended target data set and stress periods through 116.

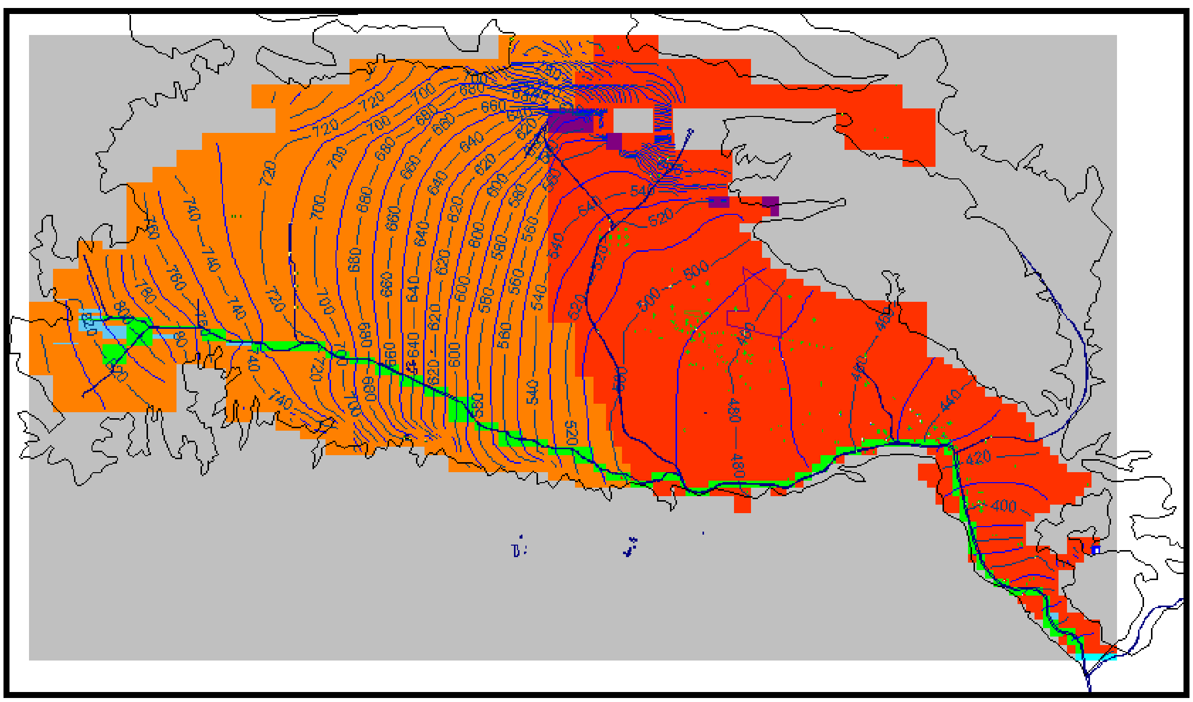


Figure A15: The three hydraulic conductivity zone model through stress period 116. Hydraulic conductivity left side is 26 ft/d and the east side is 128 ft/d. Same in upper three model layers. Model layer 4 at 16 ft/d.

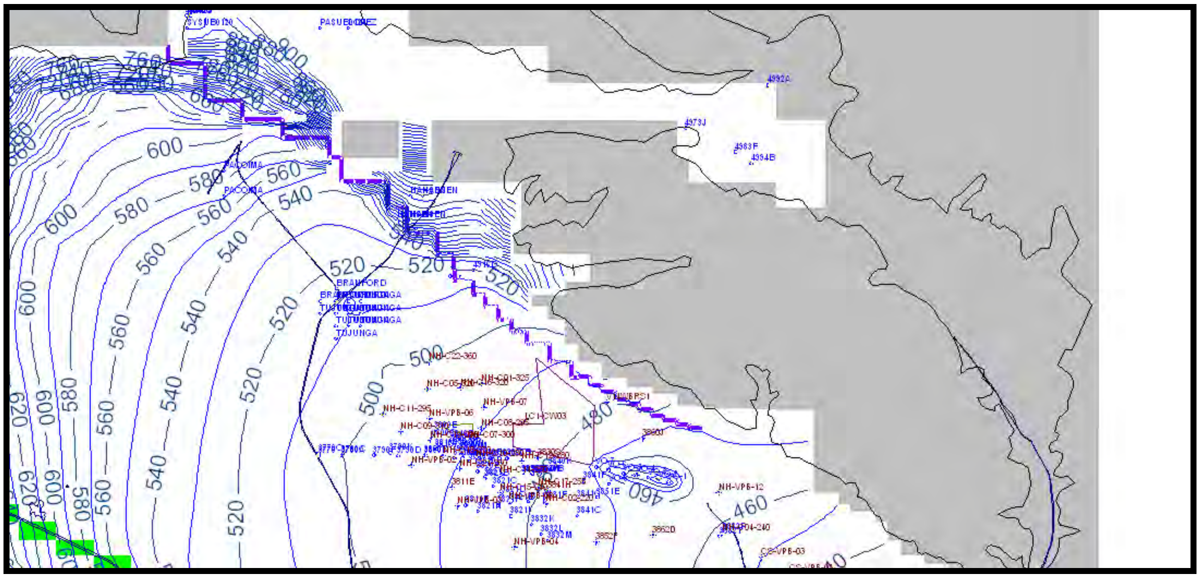


Figure A16: Location of the Verdugo Fault as represented by the MODFLOW horizontal flow barrier package (purple linear feature stretching from the Verdugo Mountains to the Sylmar Basin.

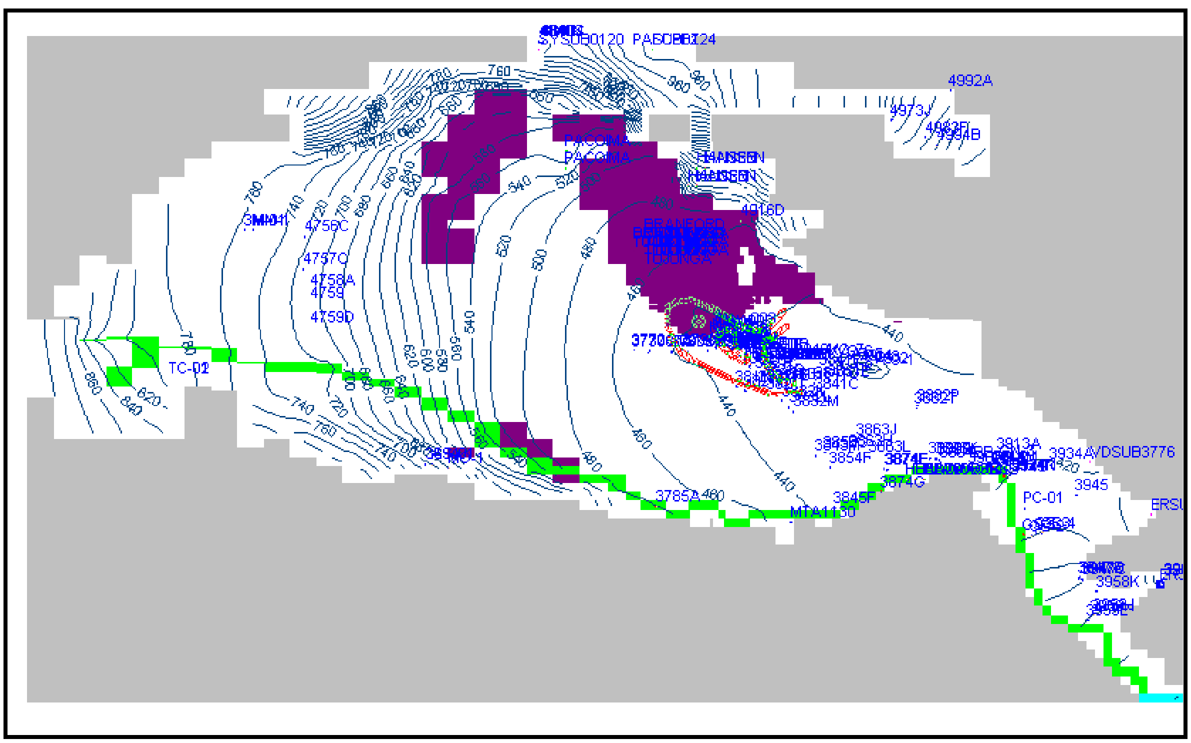


Figure A17: Extent (purple area) of model layer 1 dewatering for the Proposed Remedy NHOU extraction pumping and average SFV conditions at the end of the simulation period (year 2017).

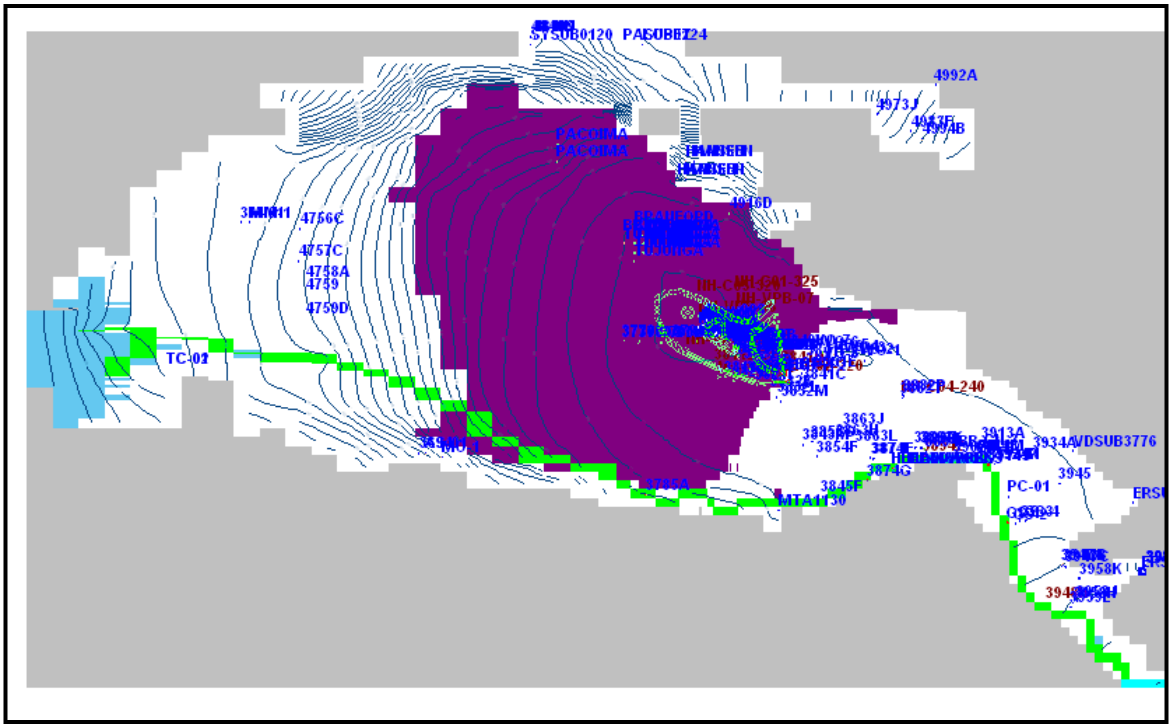


Figure A18: Extent (purple area) of model layer 1 dewatering for the for the Proposed Remedy NHOU extraction pumping and maximum (dry) SFV conditions at the end of the simulation period (year 2017).

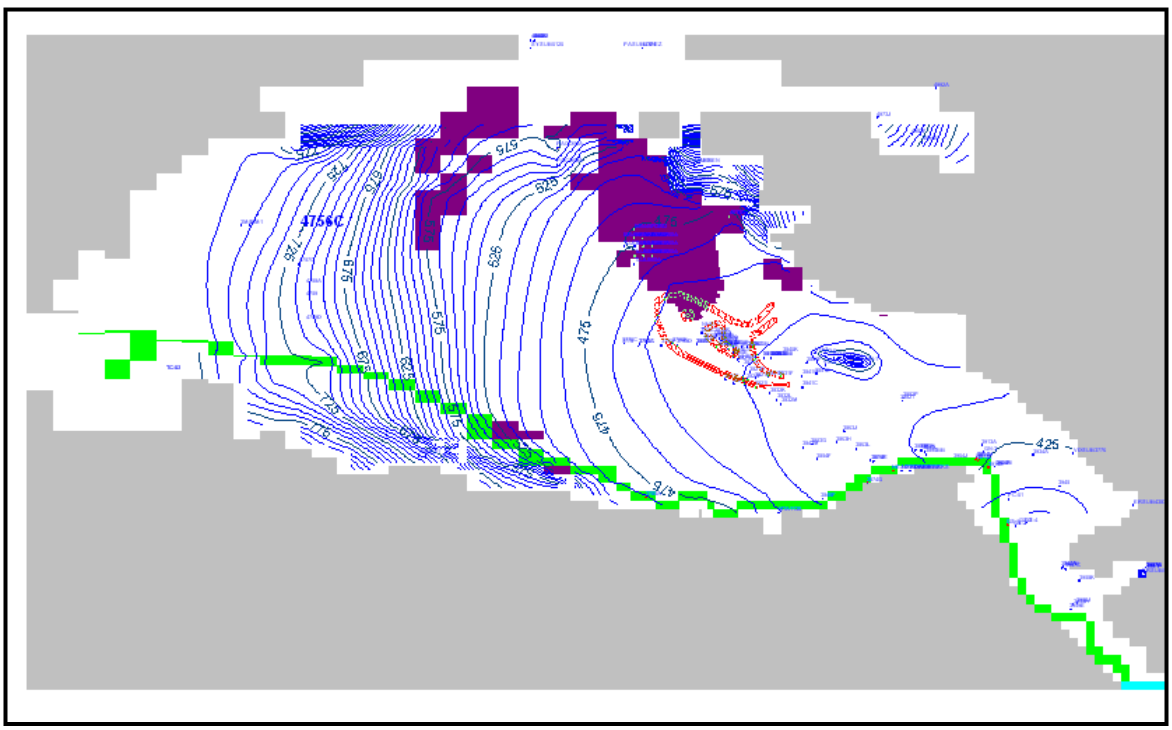


Figure A19: Extent (purple area) of model layer 1 dewatering for the No Further Action alternative pumping and average SFV conditions at the end of the simulation period (year 2017).

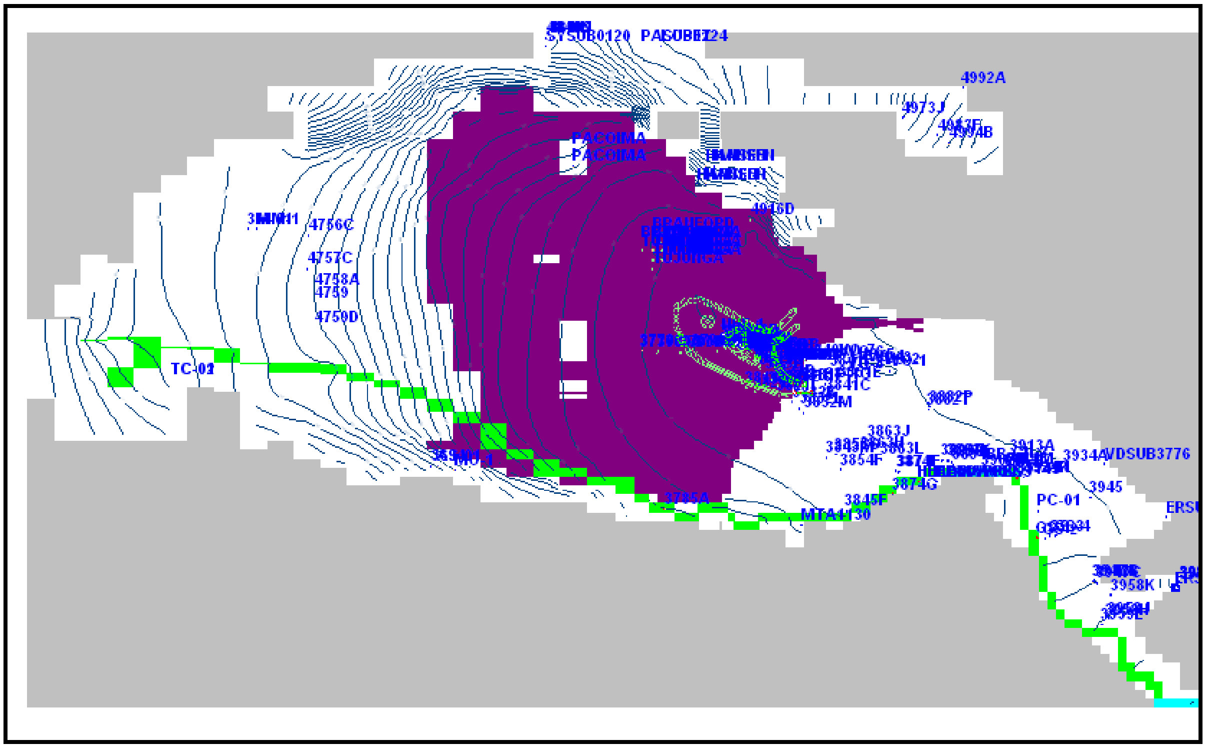


Figure A20: Extent (purple area) of model layer 1 dewatering for the No Further Action alternative pumping and maximum pumping (dry) SFV conditions at the end of the simulation period (year 2017).

ATTACHMENT 1

Table of SFBFS Screened Intervals Compared to USEPA Database Information

	Location or			FFS Calibrated Model Inputs			EPA where	MWH or DataBase Information						
Name	Alt Name	X	Y	Bot_elevation	Top_elevation	Length	other EPA data	Ref Elev.	Depth to Bottom	Depth to Top	Bot elev	Top elev	Length	Comment
3874G		4188552	4167100	331.17	454.17	123			173	50			123	
3945		4210757	4166719	424.86	454.86	30		540	285	122	255	418	163	
ERSUB4383	Eagle Rock Basin	4219500	4164500	367.1	642.7	275.6								Sub-basin input to SFV model domain
ERSUB5184	Eagle Rock Basin	4220500	4156500	302.1	533.2	231.1								Sub-basin input to SFV model domain
PASUB0124	Pacoima Basin	4160250	4217500	883.1	1170.37	287.27								Sub-basin input to SFV model domain
SYSUB0120	Sylmar Basin	4149500	4217500	840.1	1145.9	305.8								Sub-basin input to SFV model domain
VDSUB3776	Verdugo Basin	4212500	4170500	308.1	657.01	348.91								Sub-basin input to SFV model domain
3845F	Toluca Lake POA	4183158	4165227	208.1	550.44	342.34		544						Not in database
3M-01	3M Pharm	4115824	4196969	676.1	838.18	162.08								Not in database
4916D	WMD Serv of Cal	4172580	4197980	374.1	480.9	106.8		882	325	220	557	662	105	
4973J		4189675	4209459	1253.5	1330	76.5			76.5	0			76.5	
AS-01	A. Stiegler	4137233	4170216	664.1	740.9	76.8								Not in database
4916A	Vulcan	4172531	4196941	406.1	416.1	10		870	464	200	406	670	264	
4916	Vucan	4172491	4196815	214.9	423.9	209		863	364	155	499	708	209	
3914L	CS-45	4201356	4169701	190.87	422.87	232		456	328	50	128	406	278	
3914M	CS-46	4201353	4169931	144.87	422.87	278		458	344	50	114	408	294	Crystal Springs
3914S	CS-50	4202570	4168845	298.43	356.43	58		447	312	106	135	341	206	Crystal Springs; ref. elev from MWH DEM
3904J	CS-52	4198565	4169869	162.6	292.6	130		462	300	170	162	292	130	Crystal Springs
3831H	EW-1	4176975	4179393	-155.2	459.8	615	665	672	820	205	-148	467	615	Erwin well field
3811F	EW-10	4171951	4179074	78.2	474.2	396	678	676	600	204	76	472	396	Erwin well field
3821I	EW-2A	4175587	4178206	179.77	464.77	285	655	659	490	205	169	454	285	
3831G	EW-3	4177948	4178637	-136.2	301.8	438	656	650	792	66	-136	590	726	Erwin well field
3821F	EW-4	4174579	4179079	155.6	462.6	307	665	669	514	207	155	462	307	Erwin well field
3831F	EW-5	4178287	4179433	132.4	434.4	302	664	660	532	230	128	430	302	Erwin well field
3821H	EW-6	4172936	4178585	-24.9	457.1	482	669	671	694	212	-23	459	482	Erwin well field
4983F	Fenwick-1	4193688	4207527	1280.6	1336.6	56		1402	236	66	1166	1336	170	
3694		4136500	4170249	664.1	740.9	76.8								Not in database
4994B	FH-3	4194963	4206585	1290.6	1312.6	22		1457	274	145	1183	1312	129	Forest Hill
3947A	FL-2	4211094	4157236	333.05	431.05	98		429.7	171	73	258.7	356.7	98	Forest Lawn
3947B	FL-3	4211344	4157355	284.9	368.9	84		440	156	72	284	368	84	Forest Lawn
3947C	FL-4	4211537	4157124	276.9	360.9	84		435	159	75	266	360	94	Forest Lawn
3958K	FL-7	4213101	4155687	201.2	339.7	138.5		411	227.5	71.5	184	340	156	Forest Lawn
3903A	GV-11	4198500	4172840	116.1	176.1	60		488	610	312	-122	176	298	
3913G	GV-15	4201824	4171256	-23.1	213.9	237		471	462	258	9	213	204	
3913A	GV-1	4201845	4171473	-13.45	356.55	370		471	476	112	-5	359	364	
GN-1	Glendale	4201083	4169803	275	380	105		460	136	80	324	380	56	Glendale extraction
GN-2	Glendale	4201288	4170039	275	380	105		460	185	80	275	380	105	Glendale extraction
GN-3	Glendale	4202079	4170653	289	389	100		464	175	75	279	379	100	Glendale extraction
GN-4	Glendale	4201197	4169933	80	260	180		460	380	200	80	260	180	Glendale extraction
GS-1	Glendale	4204776	4162188	279	374	95		425	146	51	279	374	95	Glendale extraction
GS-2	Glendale	4205562	4162077	269	364	95		427	158	63	259	354	95	Glendale extraction
GS-3	Glendale	4206241	4162372	272	362	90		426	174	84	272	362	90	Glendale extraction
GS-4	Glendale	4206885	4162364	280	375	95		453	173	78	270	365	95	Glendale extraction
3924N	STPT-1	4203529	4169070	466.5	466.5	0		466	424	0	42	466	424	
3924R	STPT-2	4203401	4169009	208.8	326.8	118		466	330	140	136	326	190	
3894BB	HW-25	4195370	4170405	192.05	390.05	198		474	323	105	151	369	218	Ref. elev. MWH DEM
3893L	HW-26	4195016	4170715	83.05	390.05	307		476	336	105	140	371	231	
3893K	HW-27	4194728	4170931	296.35	397.35	101		478	412	104	66	374	308	Ref. elev. MWH DEM
3893M	HW-28	4194386	4171107	174.3	242.3	68		480	445	238	35	242	207	

	Location or			FFS Calibrated Model Inputs			EPA where	MWH or DataBase Information						
Name	Alt Name	X	Y	Bot_elevation	Top_elevation	Length	other EPA data	Ref Elev.	Depth to Bottom	Depth to Top	Bot elev	Top elev	Length	Comment
3893N	HW-29	4194165	4171039	30.3	245.3	215		480	450	235	30	245	215	
3893P	HW-30	4194043	4170932	201.35	336.35	135		483	400	165	83	318	235	
3861C	LB175-E1	4185615	4181428	240.1	350.9	110.8								Not in database
3934A	M050A	4207758	4170306	299.99	324.99	25		515	253	214	262	301	39	
4840J	Mission 5	4149844	4218500	979.4	1068.4	89		1132	415	64	717	1068	351	Mission
4840K	M6	4149460	4218500	845.6	908.6	63		1138	435	230	703	908	205	"
4840S	M7	4149647	4218500	886	989	103		1134	516	145	618	989	371	"
MM-1	Glen -Verdugo	4116824	4196972	676.1	838.18	162.08								Not in database - Glendale - Verdugo
MO-1	Mobil-1	4139081	4169800	648.1	706.06	57.96								Not in database
MTA1130	Met Trans Auth	4178256	4163634	397.1	551.02	153.92								MTA - not in database
3810	NH-11	4172314	4182925	320.7	608.7	288	717	713	396	108	317	605	288	
3810A	NH-13	4171707	4182927	323.3	605.3	282	715	715	392	110	323	605	282	
3810B	NH-14A	4171063	4182873	327.3	594.3	267	714	715	387	120	328	595	267	
3790B	NH-15	4165737	4184093	274.6	414.6	140	735	734	460	126	274	608	334	
3820D	NH-16	4173979	4182845	309.4	565.4	256	707	709	400	144	309	565	256	
3820C	NH-17	4174630	4182854	305.1	566.1	261	711	709	406	145	303	564	261	
3820B	NH-18	4175290	4182856	306.6	562.6	256	708	707	401	145	306	562	256	
3830D	NH-19	4176516	4181608	302.6	545.6	243	691	693	388	145	305	548	243	
3800	NH-2	4168693	4183048	344.5	613.5	269	718	718	374	105	344	613	269	
3830C	NH-20	4177293	4181602	279.8	541.8	262	690	687	408	146	279	541	262	
3830B	NH-21	4177929	4181604	295.2	540.2	245	687	685	394	149	291	536	245	
3790C	NH-22	4165494	4183052	262.6	407.6	145	721	723	460	166	263	557	294	
3790D	NH-23	4166493	4183059	261	499	238	721	723	460	222	263	501	238	
3800C	NH-24	4169239	4184434	199.1	527.1	328	733	733	534	206	199	527	328	
3790F	NH-25	4164558	4183103	179.9	559.9	380	714	723	540	160	183	563	380	
3790E	NH-26	4165830	4183077	164.9	404.9	240	720	725	555	220	165	500	335	
3820F	NH-27	4173018	4182905	-29.8	502.2	532	710	712	742	210	-30	502	532	
3810K	NH-28	4172316	4182876	-46.3	463.7	510	714	712	760	250	-48	462	510	
3810L	NH-29	4171714	4182865	50.4	499.4	449	714	713	664	215	49	498	449	
3800D	NH-30	4168688	4183134	42.6	463.6	421	719	718	676	255	42	463	421	
3810T	NH-31	4169513	4183505	85.5	516.5	431	722	724	636	205	88	519	431	
3770C	NH-32	4160100	4183241	43	451	408	715	720	672	264	48	456	408	
3780C	NH-33	4162005	4183138	-7	595	602	725	723	732	130	-9	593	602	
3790G	NH-34	4165584	4184271	12.7	412.7	400	730	730	720	202	10	528	518	
3830N	NH-35	4177378	4181616	8.32	443.32	435	700	688	695	260	-7	428	435	
3790H	NH-36	4165517	4184090	32.09	432.09	400	730	729	720	265	9	464	455	
3790J	NH-37	4165390	4184278	-157.91	432.09	590	730	729	910	230	-181	499	680	
3810M	NH-38	4171751	4183403	-54.38	440.62	495	720	721	795	300	-74	421	495	
3810N	NH-39	4171562	4183595	-89.38	440.62	530	720	723	830	300	-110	420	530	
3780A	NH-4	4162003	4183043	148	531	383	720	722	578	195	144	527	383	
3810P	NH-40	4171368	4183796	-103.38	432.62	536	720	725	844	308	-119	417	536	
3810Q	NH-41	4171026	4184139	140.98	502.98	362	730	729	610	248	119	481	362	
3810R	NH-42	4170800	4184366	36.26	468.26	432	730	731	712	280	19	451	432	
3790K	NH-43A	4165871	4183300	117.56	432.56	315	725	725	630	280	95	445	350	
3790L	NH-44	4165844	4183605	-32.44	407.56	440	725	725	780	340	-55	385	440	
3790M	NH-45	4165819	4183861	-32.44	407.56	440	725	725	780	340	-55	385	440	
3810S	NH-5	4169549	4183709	330.6	611.6	281	722	726	391	110	335	616	281	
3770	NH-7	4160090	4183047	179	563	384	714	718	535	151	183	567	384	
3800E	NHE-1	4169408	4185063	486.47	572.47	86		739.5	276	190	463.5	549.5	86	

	Location or			FFS Calibrated Model Inputs			EPA where	MWH or DataBase Information						
Name	Alt Name	X	Y	Bot_elevation	Top_elevation	Length	other EPA data	Ref Elev.	Depth to Bottom	Depth to Top	Bot elev	Top elev	Length	Comment
3810U	NHE-2	4170864	4183966	437.33	547.33	110		723.9	300	190	423.9	533.9	110	Ref. elev. For NHE wells from data in
3810V	NHE-3	4171506	4183321	454.62	550.62	96		716.9	286	190	430.9	526.9	96	table AWCSUMRY.xls less 1.5 ft.
3810W	NHE-4	4172277	4182633	441.22	541.22	100		709.5	280	180	429.5	529.5	100	
3820H	NHE-5	4173009	4182206	453.48	539.48	86		701.6	266	180	435.6	521.6	86	
3821J	NHE-6	4173495	4181349	326.72	524.72	198		692.4	378	180	314.4	512.4	198	
3830P	NHE-7	4176487	4181598	432.87	522.87	90		690.8	270	180	420.8	510.8	90	
3831K	NHE-8	4177890	4181610	423.32	523.32	100		686.2	280	180	406.2	506.2	100	
3959E	P-4	4212105	4152432	176.4	308.4	132		366	234	58	132	308	176	
3958H	P-6	4212483	4152991	177.7	282.7	105		382	253	100	129	282	153	
3958J	P-7	4212904	4153145	160.6	316.6	156		382	222	66	160	316	156	
PC-01		4204939	4165197	285.1	465.48	180.38								Not in database
3851J	PSD-11A	4183422	4179880	26.1	357.9	331.8		638						Not in database
3851E	PSD-12	4182566	4179728	-93	466	559		644	737	178	-93	466	559	
3851K	PSD-13A	4182252	4178548	24.1	350.9	326.8		631						Not in database
3882T	PSD-15	4192413	4176598	283.1	408.1	125		558	453	153	105	405	300	
3841F	PSD-17	4181480	4181017	-71.1	448.9	520		663	750	230	-87	433	520	
3841G	PSD-18	4180967	4179520	-207.02	370.98	578		651	878	300	-227	351	578	
3841C	PSD-6A	4180970	4178227	208.86	526.86	318		637	453	135	184	502	318	Ref. elev. MWH DEM
3882P	PSD-7	4192703	4176943	-49.9	493.1	543		558	608	65	-50	493	543	
4759D	R-10	4123391	4185944	504	709	205		743	294	32	449	711	262	
3650B		4123181	4183267	460	599	139		738						Not in database
4759	R-5	4123394	4188569	640	674	34		750	258	76	492	674	182	
4757C	R-6	4122559	4192457	658	698	40		775	180	74	595	701	106	
4756C	R-8	4122720	4196212	651.6	797.6	146		802	294	35	508	767	259	
4758A	R-9	4123394	4190102	616	678	62		762	253	80	509	682	173	Ref. elev. MWH DEM
4909E	RT-1	4168022	4187191	-18	402	420		763	780	360	-17	403	420	Rinaldi-Toluca
4909G	RT-10	4166931	4188453	140.28	440.28	300		773	660	360	113	413	300	Rinaldi-Toluca
4909K	RT-11	4167571	4187713	157.17	427.17	270		769	770	370	-1	399	400	Rinaldi-Toluca
4909H	RT-12	4167178	4188168	293.22	433.22	140		770	789	370	-19	400	419	Rinaldi-Toluca
4909J	RT-13	4167361	4187954	8.17	427.17	419		771	780	370	-9	401	410	Rinaldi-Toluca
4909L	RT-14	4168304	4186860	2.1	449.9	447.8		760	770	360	-10	400	410	Rinaldi-Toluca
4909M	RT-15	4168529	4186597	2.1	449.9	447.8		758	750	360	8	398	390	Rinaldi-Toluca
4898A	RT-2	4166557	4188882	-5	405	410		777	780	370	-3	407	410	Rinaldi-Toluca
4898B	RT-3	4166343	4189135	110	410	300		781	770	370	11	411	400	Rinaldi-Toluca
4898C	RT-4	4166031	4189492	10	410	400		784	770	370	14	414	400	Rinaldi-Toluca
4898D	RT-5	4165798	4189764	12	412	400		785	770	370	15	415	400	Rinaldi-Toluca
4898E	RT-6	4165350	4190284	15	415	400		790	770	370	20	420	400	Rinaldi-Toluca
4898F	RT-7	4164634	4191114	37.1	465.9	428.8		799	780	370	19	429	410	Rinaldi-Toluca
4898G	RT-8	4164458	4191319	37.1	465.9	428.8		801	780	360	21	441	420	Rinaldi-Toluca
4898H	RT-9	4164301	4191510	37.1	465.9	428.8		803	780	370	23	433	410	Rinaldi-Toluca
3987A	SP-1	4220900	4157191	346.51	491.51	145							0	
3987B	Sparklet-2	4220900	4157151	350.51	485.51	135			210	75			135	
3987F	Sparklet-3	4220900	4157044	294.51	434.51	140			266	126			140	
3987G		4220900	4157150	311.1	560.41	249.31		506						Not in database - Eagle Rock Basin
3785A	Sport. Lodge	4162834	4165417	453.1	647.1	194								Not in database
4916B	Sun Valley	4171323	4198474	450.2	502.2	52		712	382	159	330	553	223	
TC-01		4107145	4179956	699.1	807.9	108.8								Not in database - same specs/loc as TC02
4992A	TGPLT	4196312	4212900	1136.1	1479.9	343.8								Not in database
4887C	TJ-01	4161069	4194684	-309.9	472.9	782.8	841	820	780	400	40	420	380	Tujunga well field

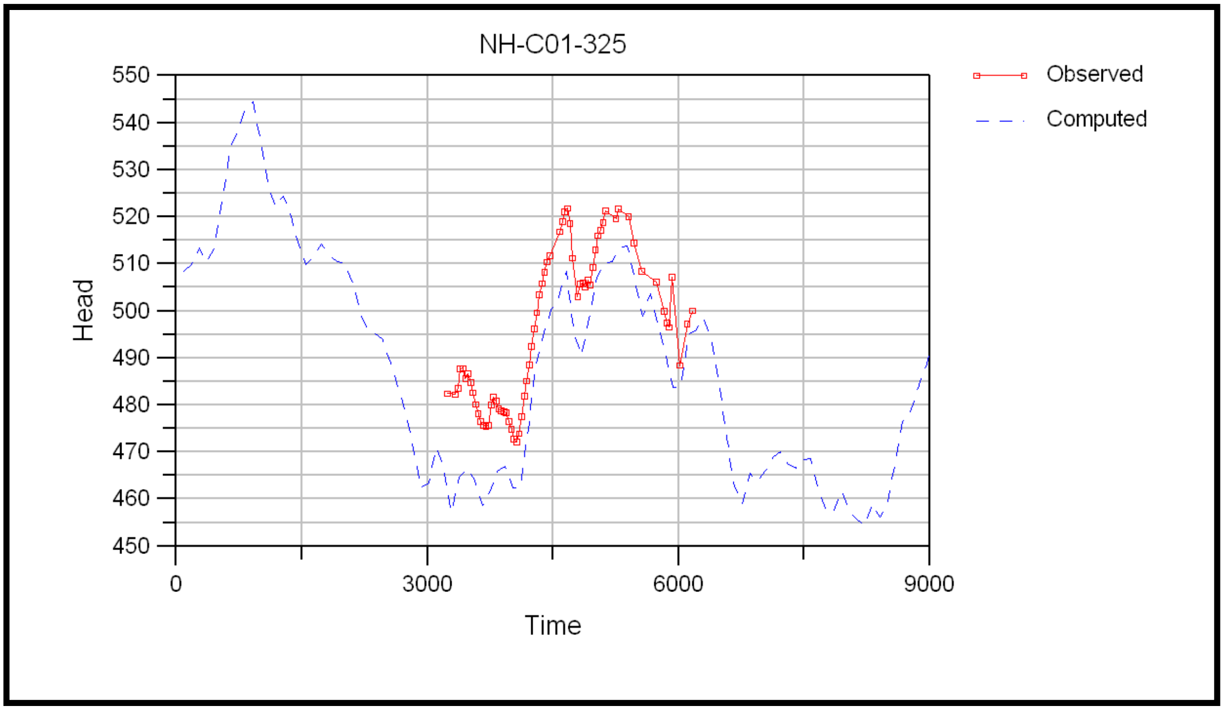
	Location or			FFS Calibrated Model Inputs			EPA where	MWH or DataBase Information						
Name	Alt Name	X	Y	Bot_elevation	Top_elevation	Length	other EPA data	Ref Elev.	Depth to Bottom	Depth to Top	Bot elev	Top elev	Length	Comment
4887D	TJ-02	4161295	4194884	-309.9	472.9	782.8	841	820	780	400	40	420	380	Tujunga well field
4887E	TJ-03	4161516	4195090	-296.9	480.9	777.8		820	780	400	40	420	380	Tujunga well field
4887F	TJ-04	4161745	4195280	-296.9	480.9	777.8	833	822	780	400	42	422	380	Tujunga well field
4887G	TJ-05	4161966	4195487	-296.9	480.9	777.8	837	825	780	400	45	425	380	Tujunga well field
4887H	TJ-06	4162200	4195680	-320.9	484.9	805.8	810	828	780	400	48	428	380	Tujunga well field
4887J	TJ-07	4162421	4195873	-320.9	484.9	805.8	843	836	780	400	56	436	380	Tujunga well field
4887K	TJ-08	4162650	4196073	-308.9	492.9	801.8	848	841	780	400	61	441	380	Tujunga well field
4886B	TJ-09	4162872	4196267	-308.9	492.9	801.8	853	842	780	400	62	442	380	Tujunga well field
4886C	TJ-10	4163097	4196463	-325.9	491.9	817.8		842	780	400	62	442	380	Tujunga well field
4886D	TJ-11	4163328	4196666	-325.9	491.9	817.8		842	780	400	62	442	380	Tujunga well field
4886E	TJ-12	4163564	4196873	-325.9	491.9	817.8	859	843	780	370	63	473	410	Tujunga well field
TC-02		4107145	4179956	699.1	807.9	108.8		847	780	400	67	447	380	Not in database - see also TC-01
3863H	V-1	4184977	4171821	60.84	438.84	378		560	506	128	54	432	378	Ref. elev. MWH DEM
3863L	V-11	4187260	4171040	62.68	370.68	308		540.6	490	182	50.6	358.6	308	Verdugo basin within model domain
3853G	V-13	4182076	4171593	79.18	435.18	356		571.3	501	145	70.3	426.3	356	Verdugo basin within model domain
3840K	VMP-4	4178680	4182210	-46.69	418.31	465		695.5	755	290	-59.5	405.5	465	Verdugo basin within model domain
3843M	V-16	4181064	4171186	91.44	459.44	368			495	127			368	Verdugo basin within model domain
3863P	V-2	4184700	4172513	-23.75	263.25	287		563	600	313	-37	250	287	Verdugo basin within model domain
3854F	V-22	4182725	4169849	148.53	433.53	285		557.7	418	133	139.7	424.7	285	Verdugo basin within model domain
3844R	V-24	4181724	4169445	153.02	329.02	176		568	418	242	150	326	176	Verdugo basin within model domain
3863J	V-4	4185751	4173072	20.31	387.31	367		564	559	192	5	372	367	Verdugo basin within model domain
VO-1		4188281	4180935	355.1	545.1	190		608	325	70	326	545		Burbank extraction; bottom is packer
VO-2		4187527	4181112	357.32	537.32	180		612	322	82	330	537		Burbank extraction; elevation for the
VO-3		4186631	4181330	357.7	527.7	170		619	328	98	337	528		Burbank extraction; VO extraction wells
VO-4		4185705	4181538	351.7	531.7	180		631	346	106	330	532		Burbank extraction; In model use low
VO-5		4184681	4181627	378.91	533.91	155		637	340	110	349	534		Burbank extraction; level alarm as pump
VO-6		4183446	4181925	375.66	545.66	170		648	349	109	346	546		Burbank extraction; level elevation
VO-7		4182475	4182159	382.59	542.59	160		660	355	125	357	543		Burbank extraction
VO-8		4183475	4180761	283.71	537.71	254		646	354	153	293	492		Burbank extraction
3874E	WDP-East	4189155	4169624	389.93	452.93	63		518	286	75	232	443	211	
3874F	WDP-West	4188931	4169680	307.1	536.57	229.47		520	294	78	226	442	216	
3820E	WH-1	4172911	4181806	190	549	359		702	509	150	193	552	359	Whitnall well field
3842E	WH-10	4179355	4175499	130.9	330.9	200	621	615	490	290	125	325	200	Whitnall well field
3821B	WH-2	4173601	4181235	249.72	542.72	293	695	696	455	162	241	534	293	Whitnall well field
3821C	WH-3	4174188	4180639	258.25	530.25	272	690	687	442	170	248	520	272	Whitnall well field
3821D	WH-4	4174897	4179920	183.95	537.95	354	675	676	504	150	172	526	354	Whitnall well field
3821E	WH-5	4175568	4179299	177.6	519.6	342	665	667	492	150	175	517	342	Whitnall well field
3831J	WH-6A	4176306	4178547	-235.3	390.7	626	659	657	894	268	-237	389	626	Whitnall well field
3832K	WH-7	4177279	4177506	-185.84	403.16	589	650	643	842	253	-199	390	589	Whitnall well field
3832L	WH-8	4178051	4176722	183.4	420.4	237	645	632	461	224	171	408	237	Whitnall well field
3832M	WH-9	4178570	4176233	206.4	460.4	254	635	626	438	184	188	442	254	Whitnall well field
4916(x)	Vulcan	4172491	4196815	350.1	457.9	107.8		873						Not in database
LOPEZ		4162500	4217500	921.1	1198.12									Spreading grounds
PACOIMA		4152500	4206000	534.1	954.21									Spreading grounds
PACOIMA		4152500	4204000	510.1	942.76									Spreading grounds
HANSEN		4167500	4204000	553.1	954.94									Spreading grounds
HANSEN		4168500	4204000	572.1	967.21									Spreading grounds
HANSEN		4166500	4202000	523.1	928.9									Spreading grounds
HANSEN		4167500	4202000	539.1	932.81									Spreading grounds

	Location or			FFS Calibrated Model Inputs			EPA where	MWH or DataBase Information						
Name	Alt Name	X	Y	Bot_elevation	Top_elevation	Length	other EPA data	Ref Elev.	Depth to Bottom	Depth to Top	Bot elev	Top elev	Length	Comment
BRANFORD		4161519.82	4196500	490.1	869.5									Spreading grounds
BRANFORD		4160250	4195500	480.1	858.69									Spreading grounds
BRANFORD		4161500	4195500	481.1	859.04									Spreading grounds
TUJUNGA		4162500	4195500	485.1	855.05									Spreading grounds
TUJUNGA		4163500	4195500	488.1	851.58									Spreading grounds
TUJUNGA		4160250	4194500	476.1	846.93									Spreading grounds
TUJUNGA		4161500	4194500	473.1	848.05									Spreading grounds
TUJUNGA		4162500	4194500	477.1	848.16									Spreading grounds
TUJUNGA		4163500	4194500	483.1	848.19									Spreading grounds
TUJUNGA		4161500	4193500	476.1	837.32									Spreading grounds
TUJUNGA		4162500	4193500	475.1	837.99									Spreading grounds
TUJUNGA		4163500	4193500	480.1	839.23									Spreading grounds
TUJUNGA		4161500	4192500	472.1	826.48									Spreading grounds
HEADWORKS		4191500	4168500	289.1	500.45									Spreading grounds
HEADWORKS		4192500	4168500	281.1	499.9									Spreading grounds
HEADWORKS		4193500	4168500	276.1	499.18									Spreading grounds

(orange)	Difference between model and EPA/other data >= 10 feet
(light green)	Difference between model and EPA/other data <= 5 feet
(white)	Difference between model and EPA/other data > 5 ft but < 10 ft
(tan)	No reference elevation in the database
(yellow)	Well not in database

ATTACHMENT 2

Hydrographs of NHOU Area Observation Wells – Limited Data Set (30 Wells)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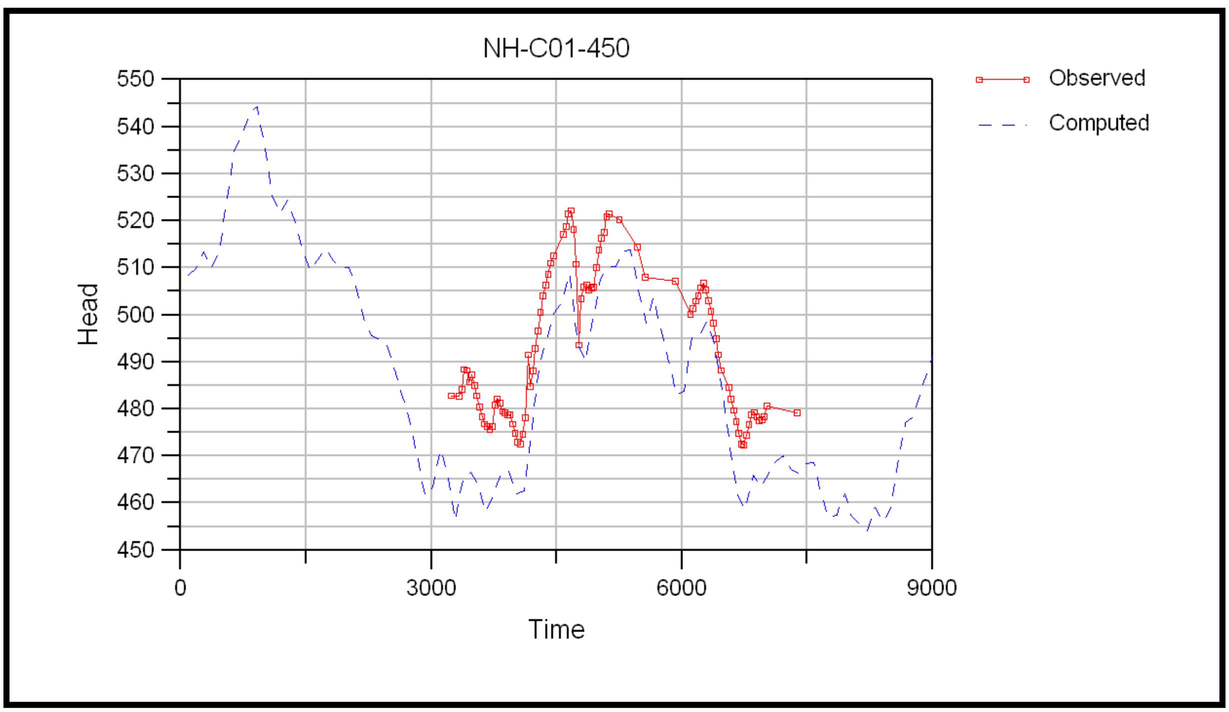
6000
9000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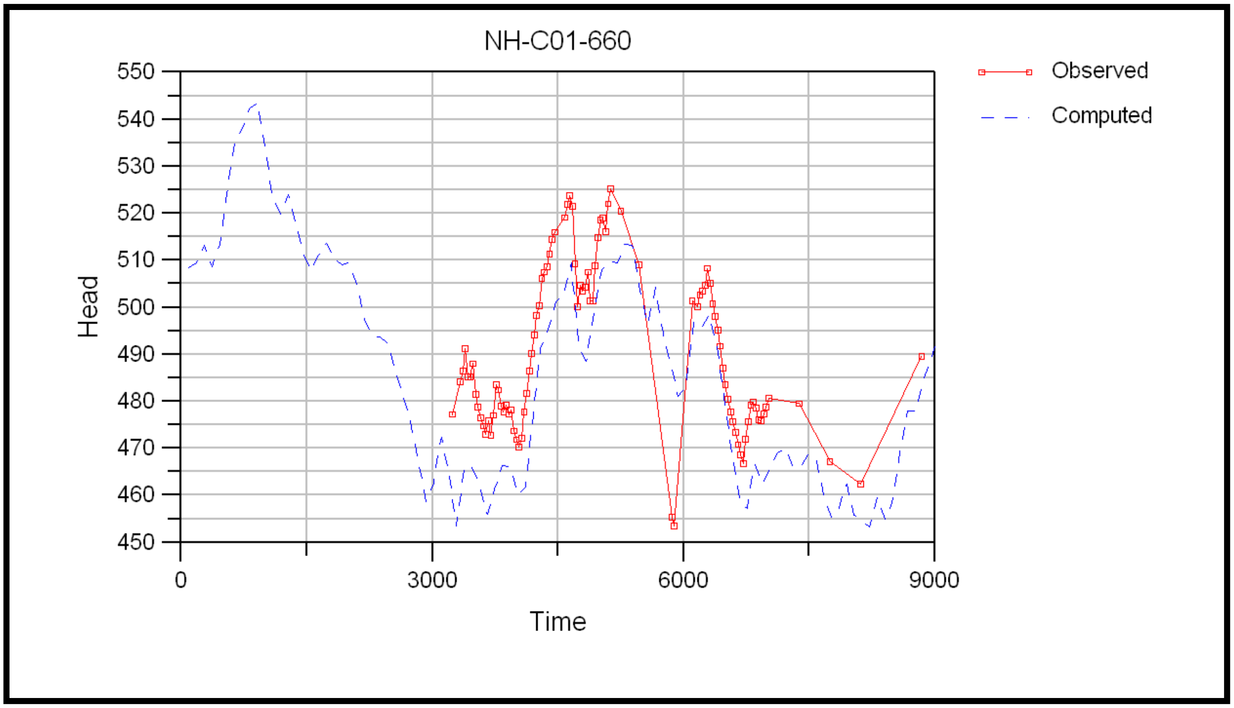
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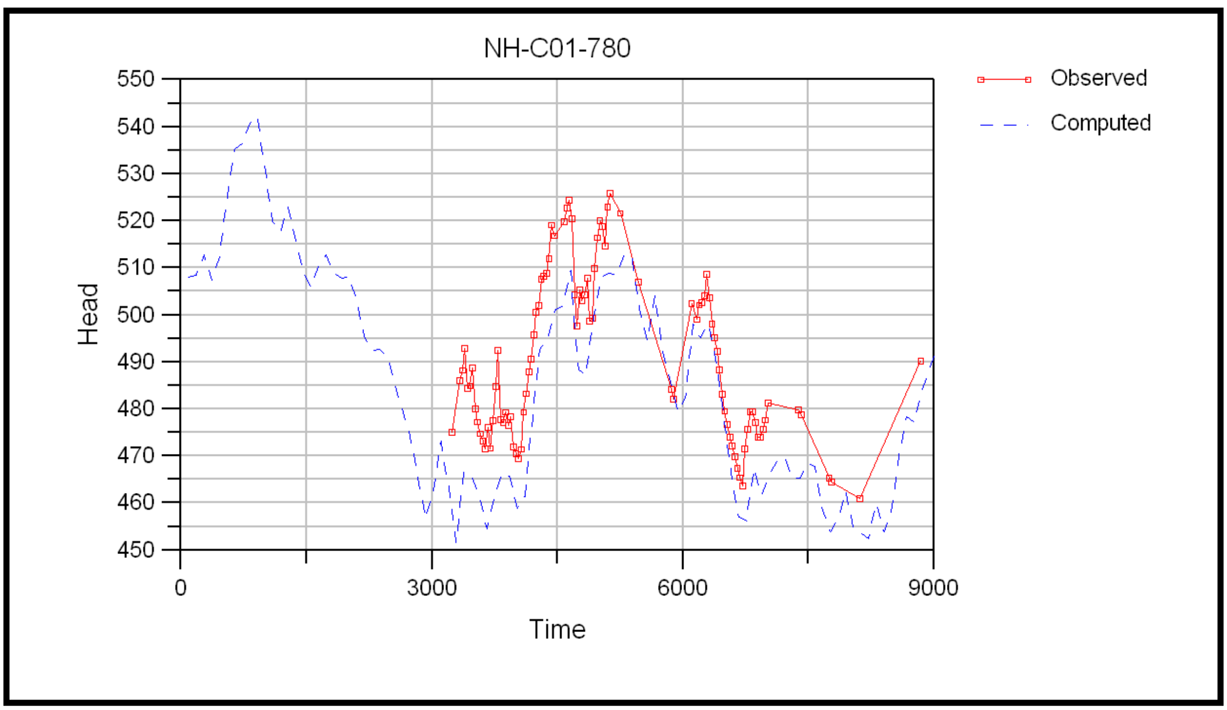
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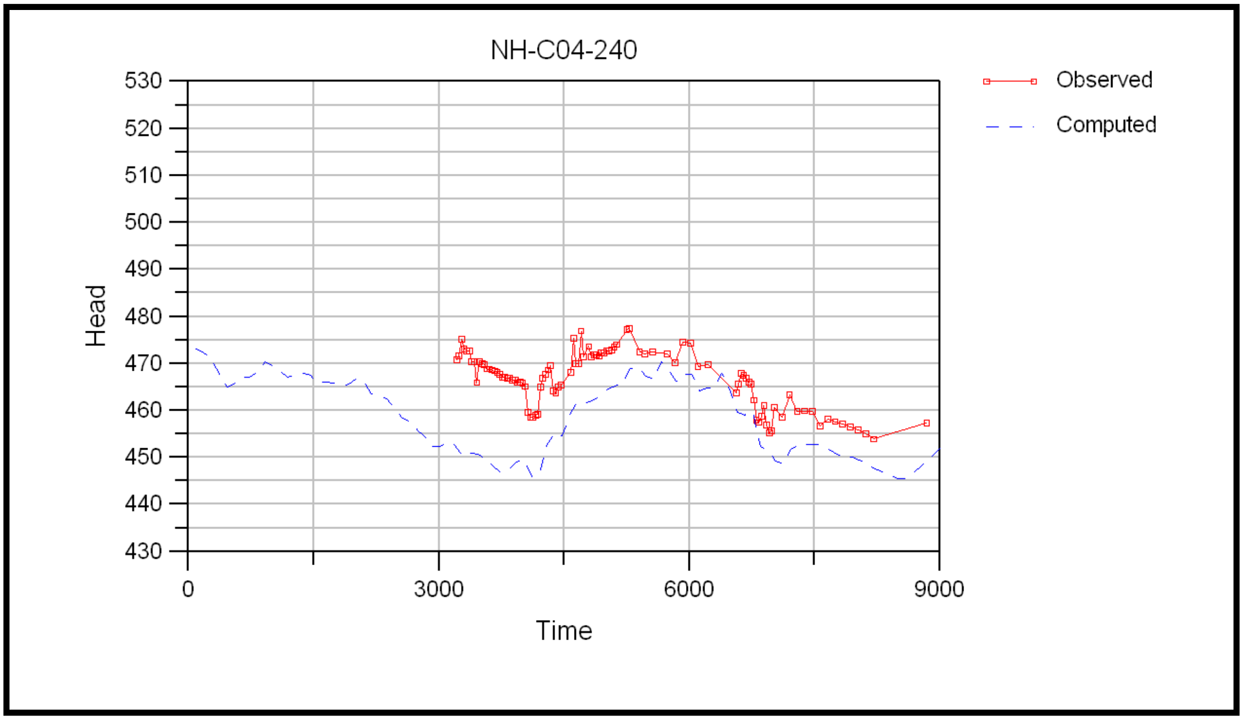

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Computed
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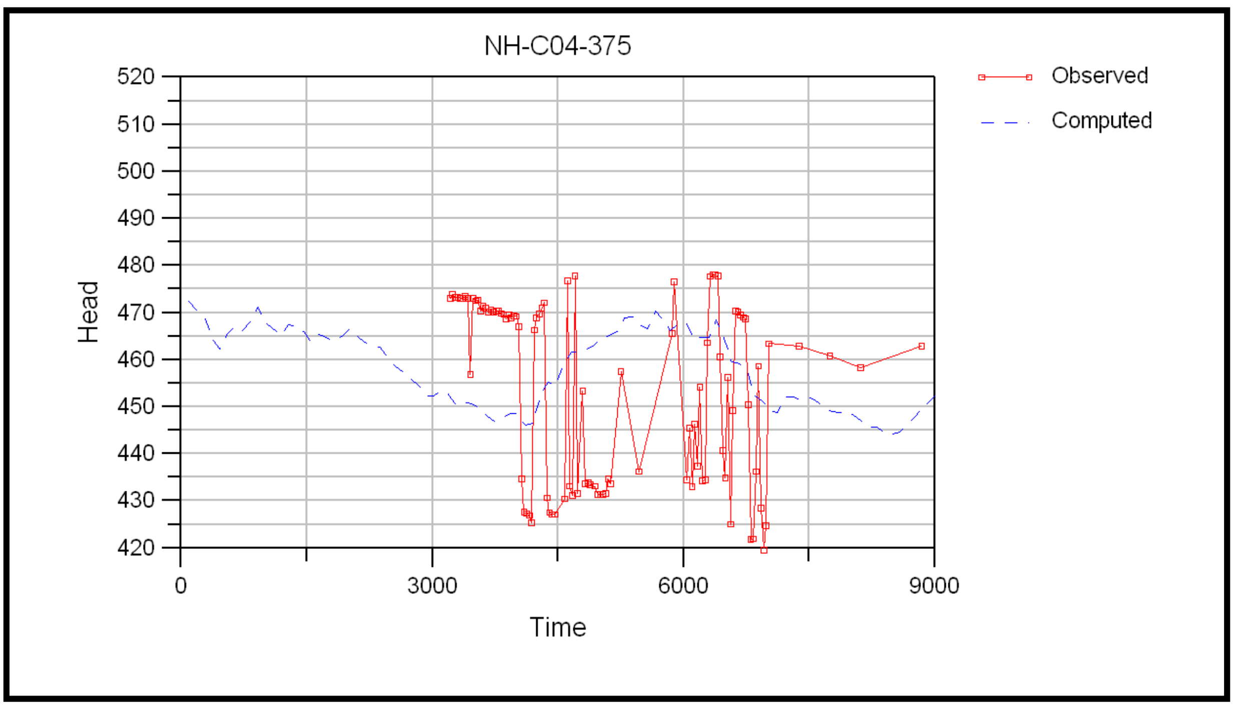

NH-C04-375
Observed
Computed
Head
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500
490
480
470
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450
440
430
420
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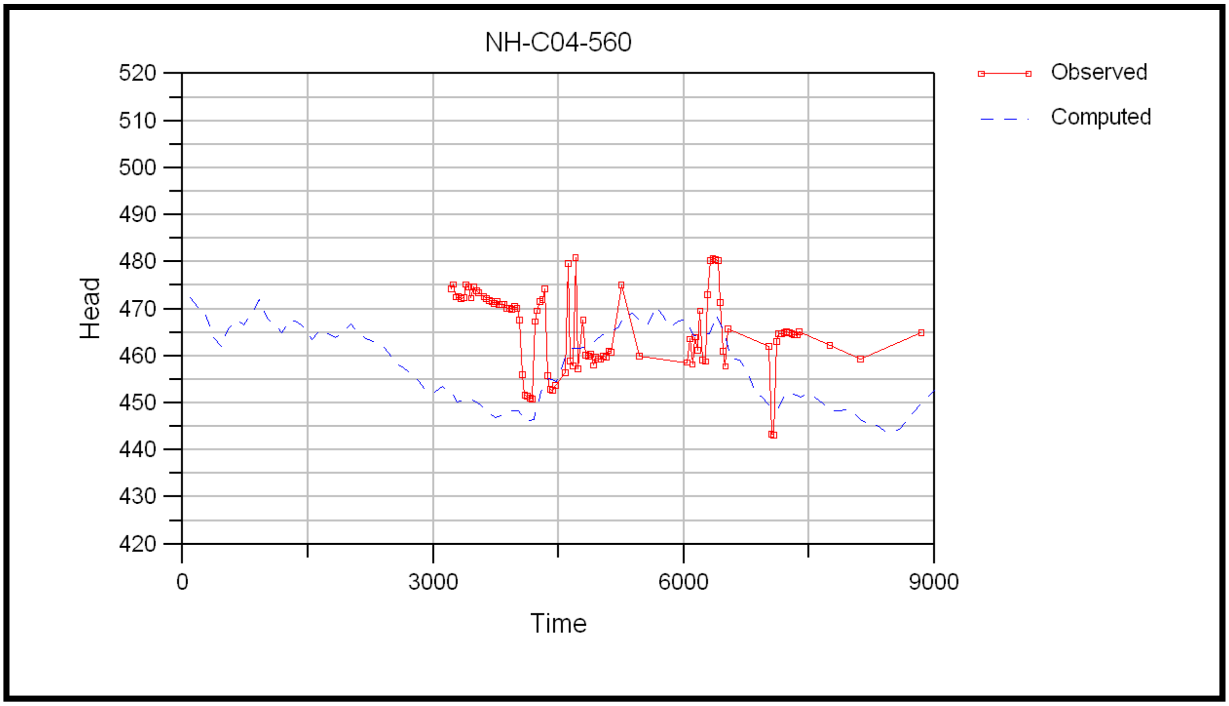
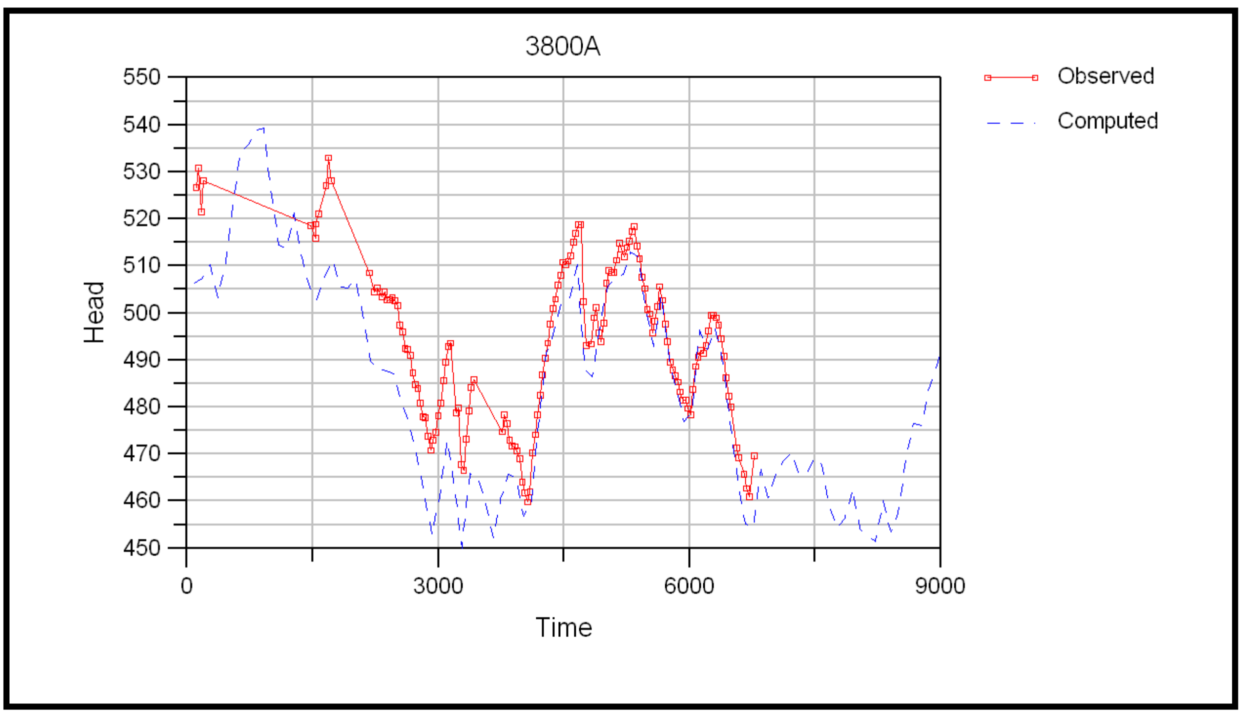
6000
9000


NH-C04-560
Observed
Computed
Head
Time
520
510
500
490
480
470
460
450
440
430
420
0
3000
6000
9000


3800A
Observed
Computed
Head
Time
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520
510
500
490
480
470
460
450
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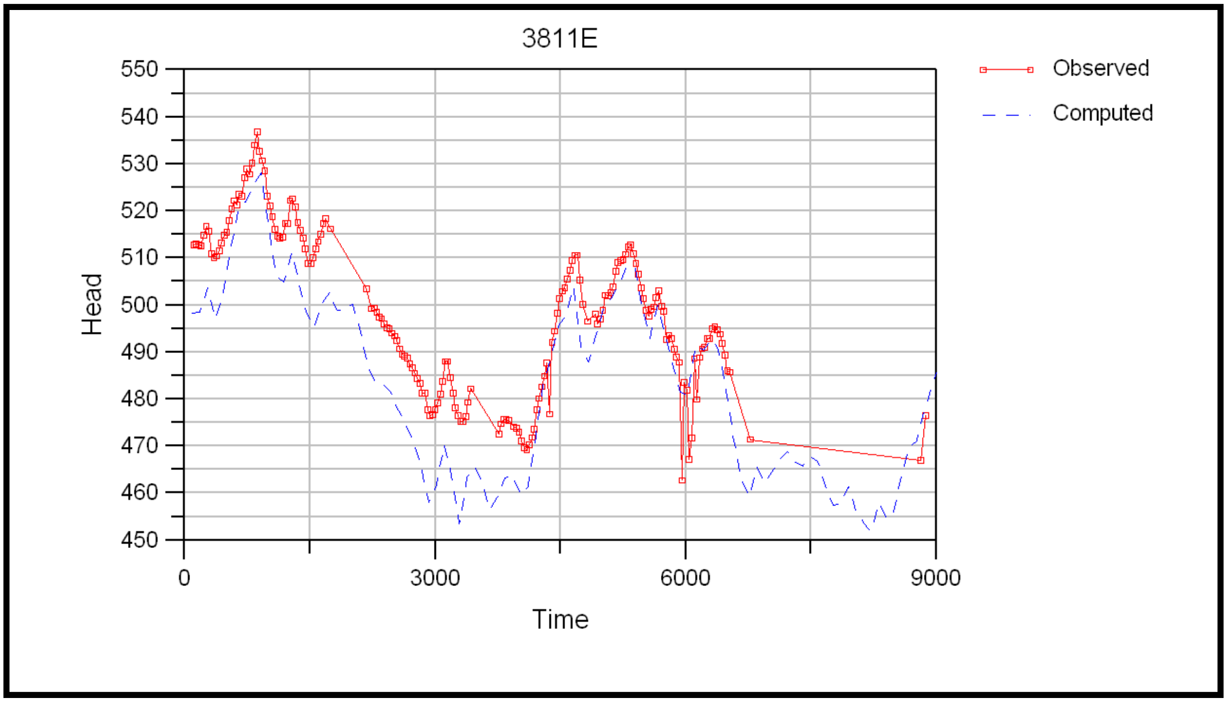
3000
6000
9000


3811E
Observed
Computed
Head
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540
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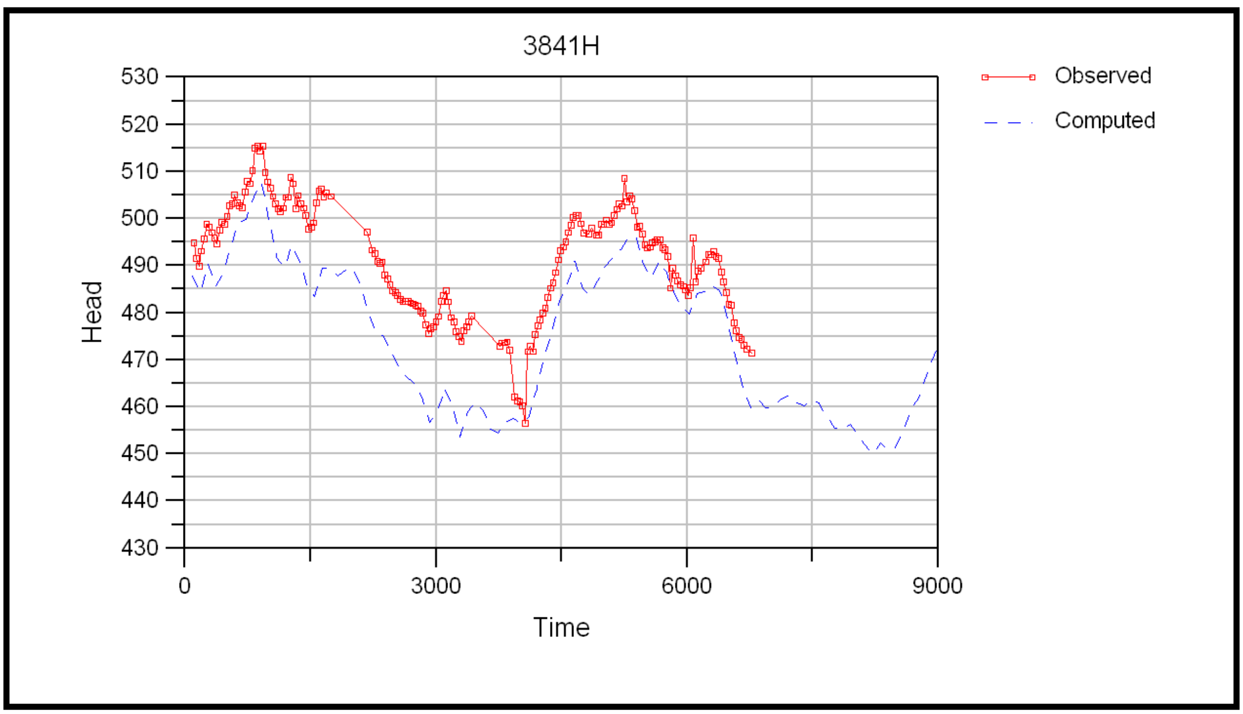
520
510
500
490
480
470
460
450
0
3000
6000
9000
Time


3841H
Observed
Computed
Head
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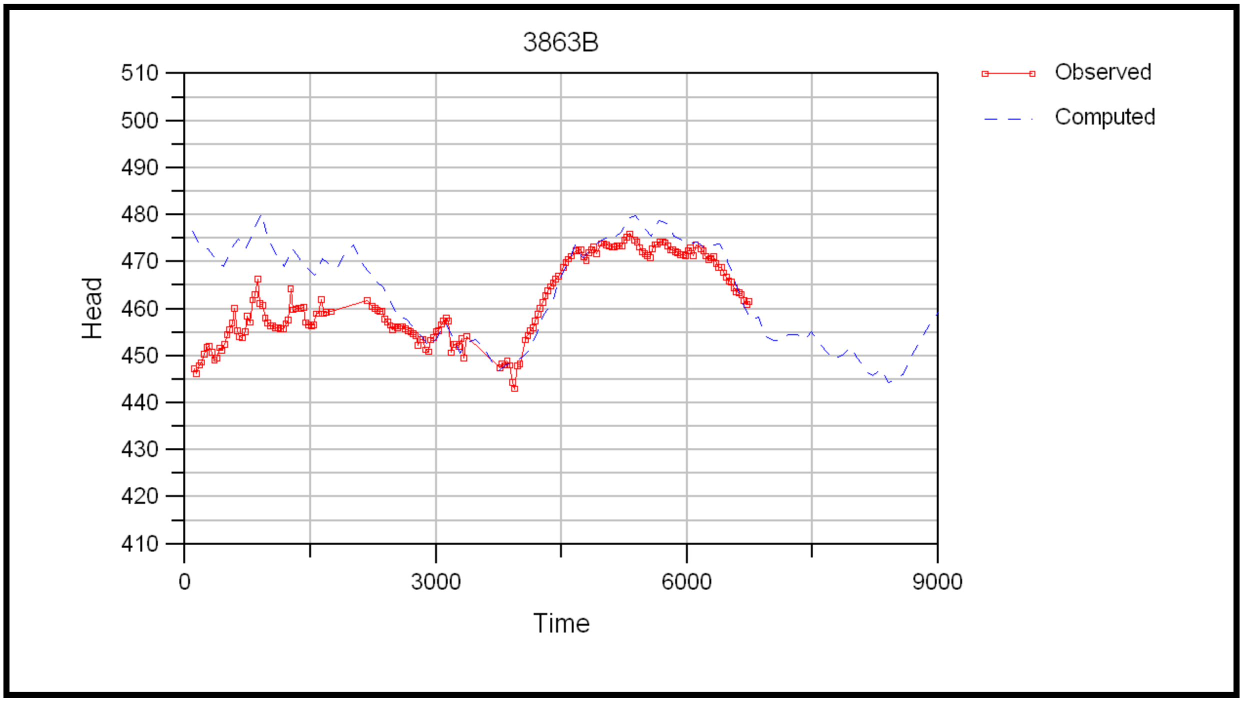
490
480
470
460
450
440
430
0
3000
6000
9000
Time


3863B
Observed
Computed
Head
510
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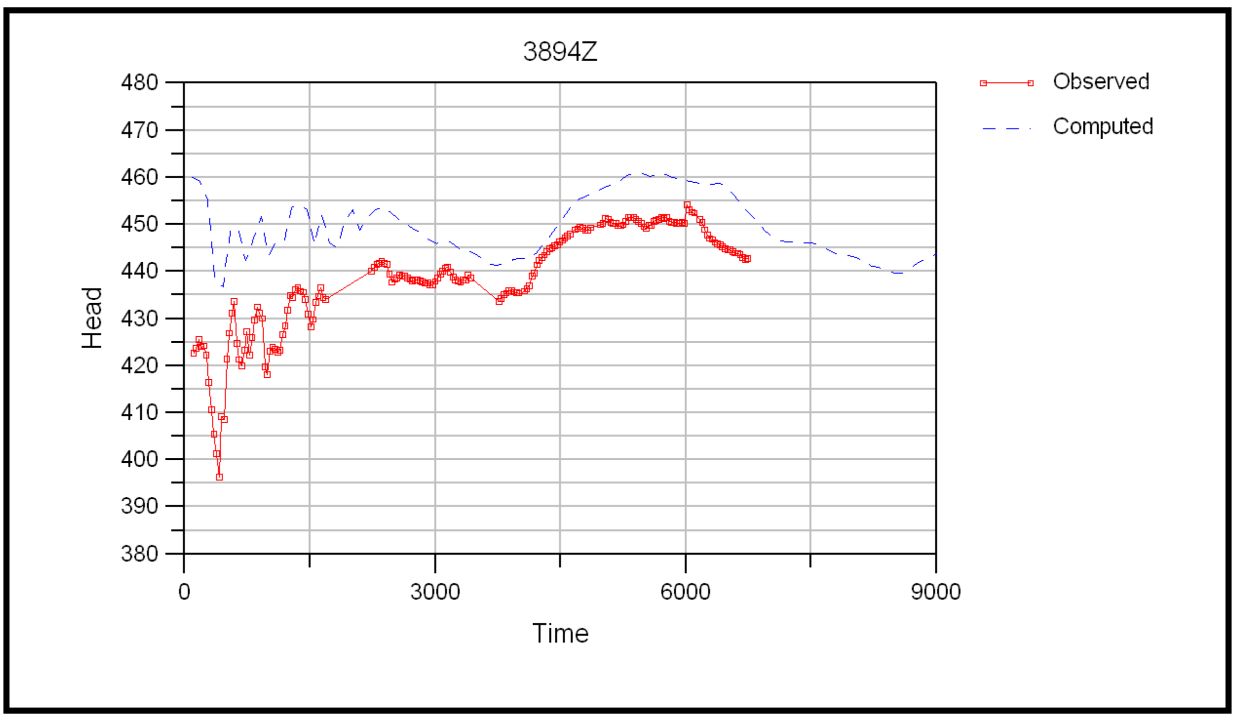
480
470
460
450
440
430
420
410
0
3000
6000
9000
Time


3894Z
Observed
Computed
Head
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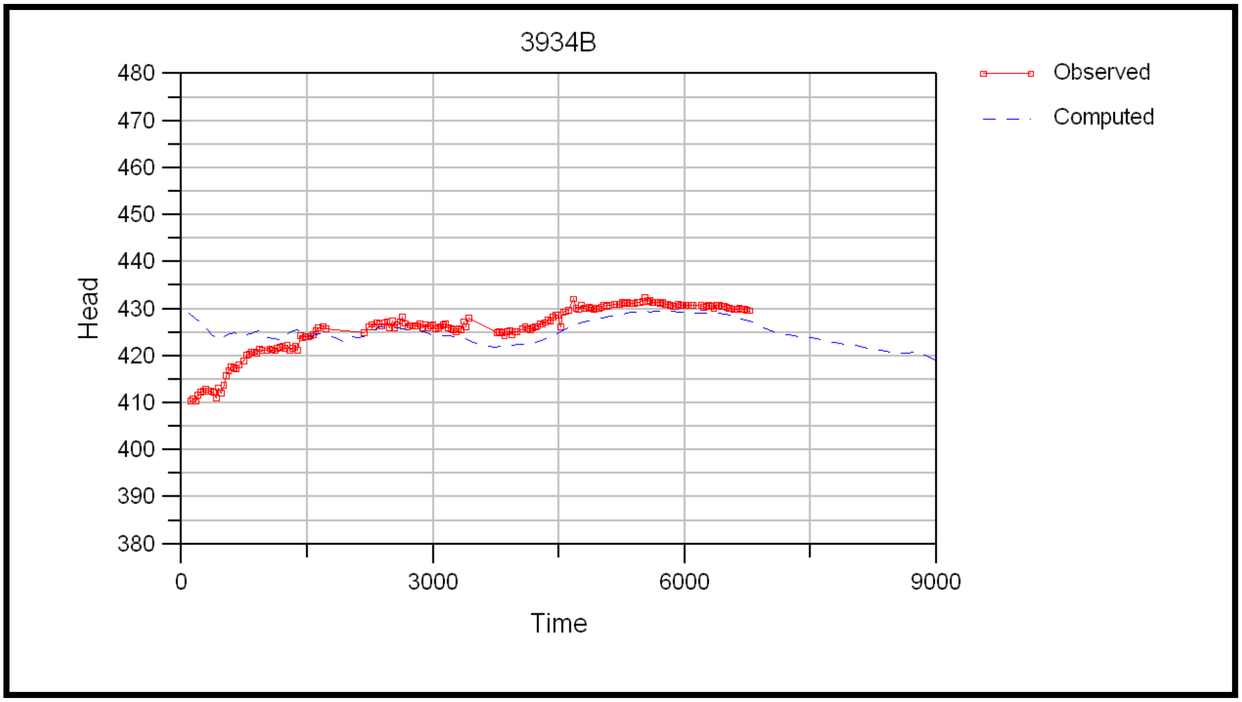
470
460
450
440
430
420
410
400
390
380
0
3000
6000
9000
Time


3934B
Observed
Computed
Head
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470
460
450
440
430
420
410
400
390
380
0
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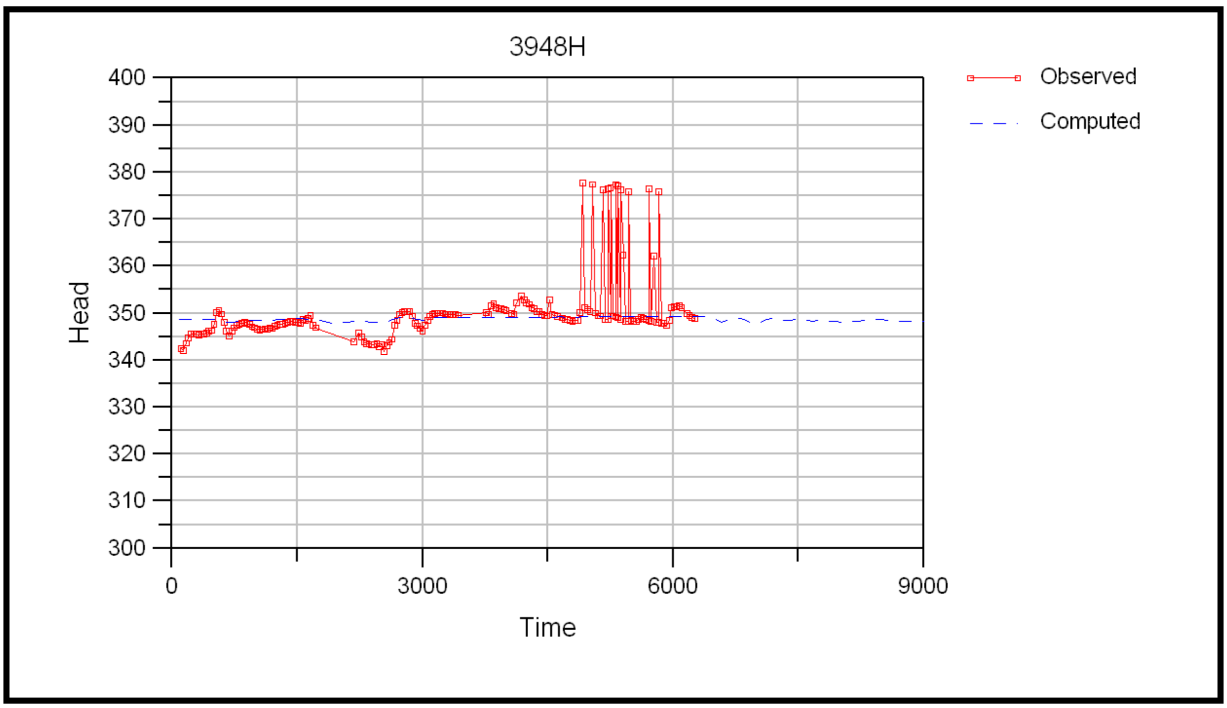
6000
9000
Time


3948H
Observed
Computed
Head
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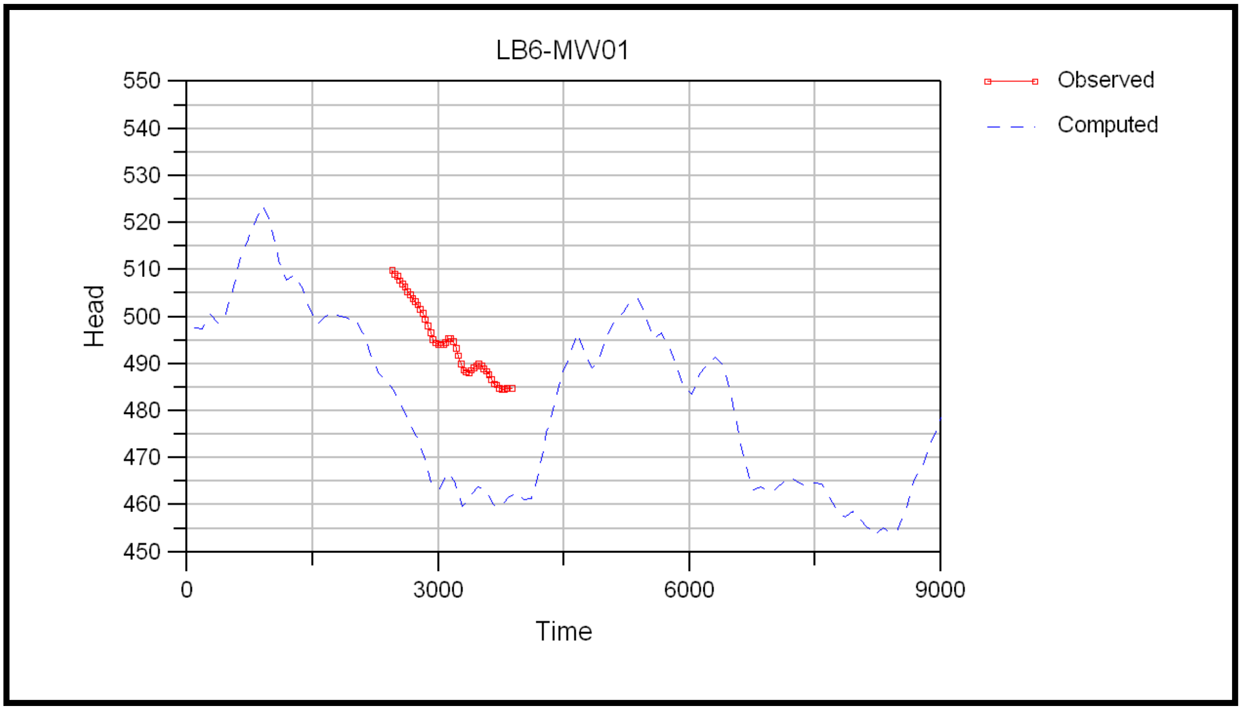
390
380
370
360
350
340
330
320
310
300
0
3000
6000
9000
Time


LB6-MW01
Observed
Computed
Head
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540
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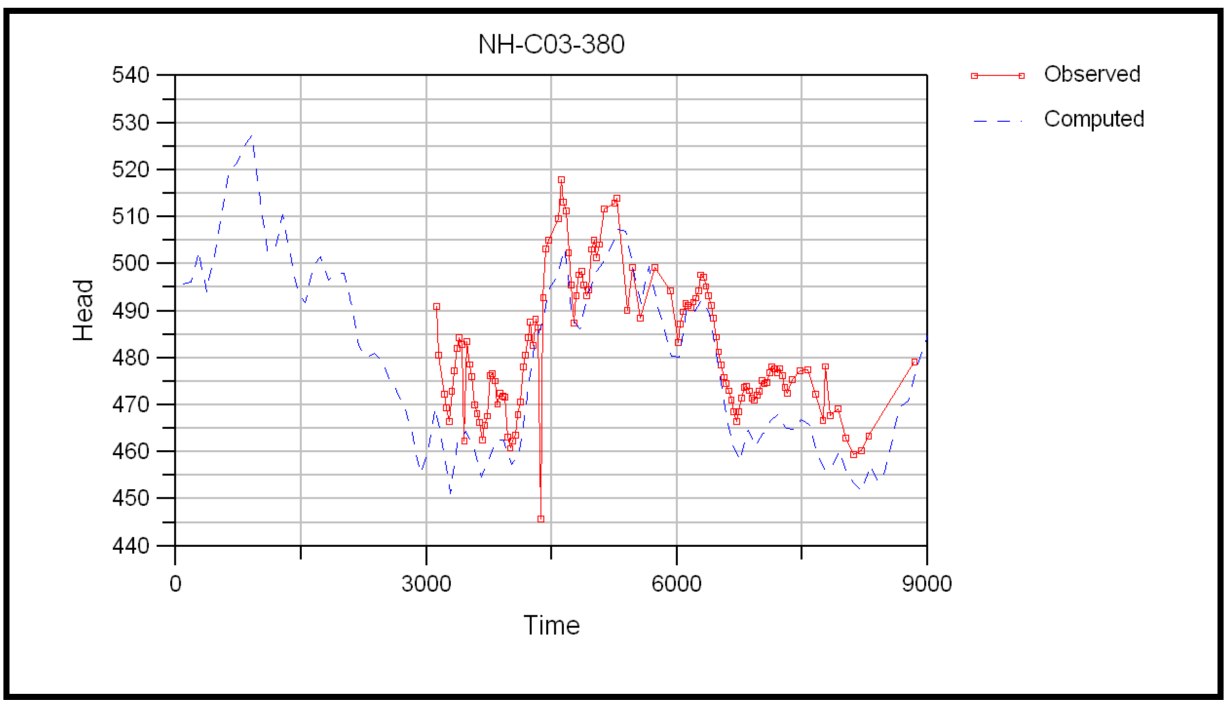
520
510
500
490
480
470
460
450
0
3000
6000
9000
Time


NH-C03-380
Observed
Computed
Head
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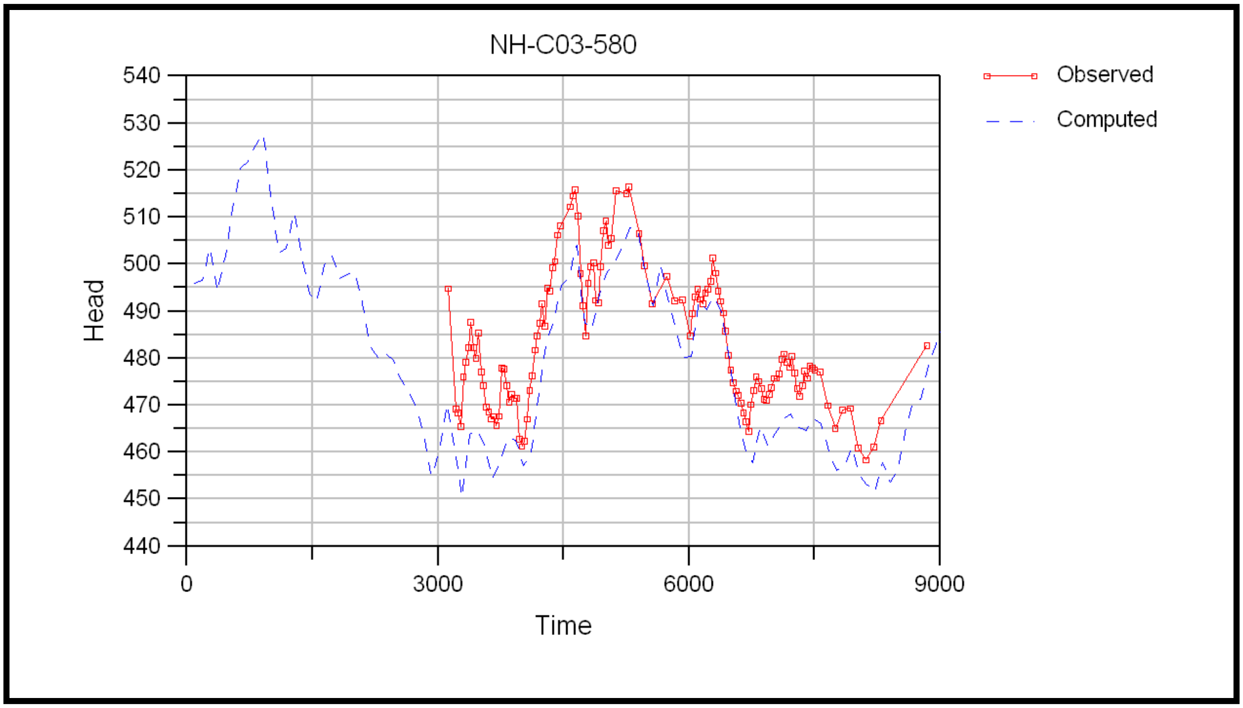
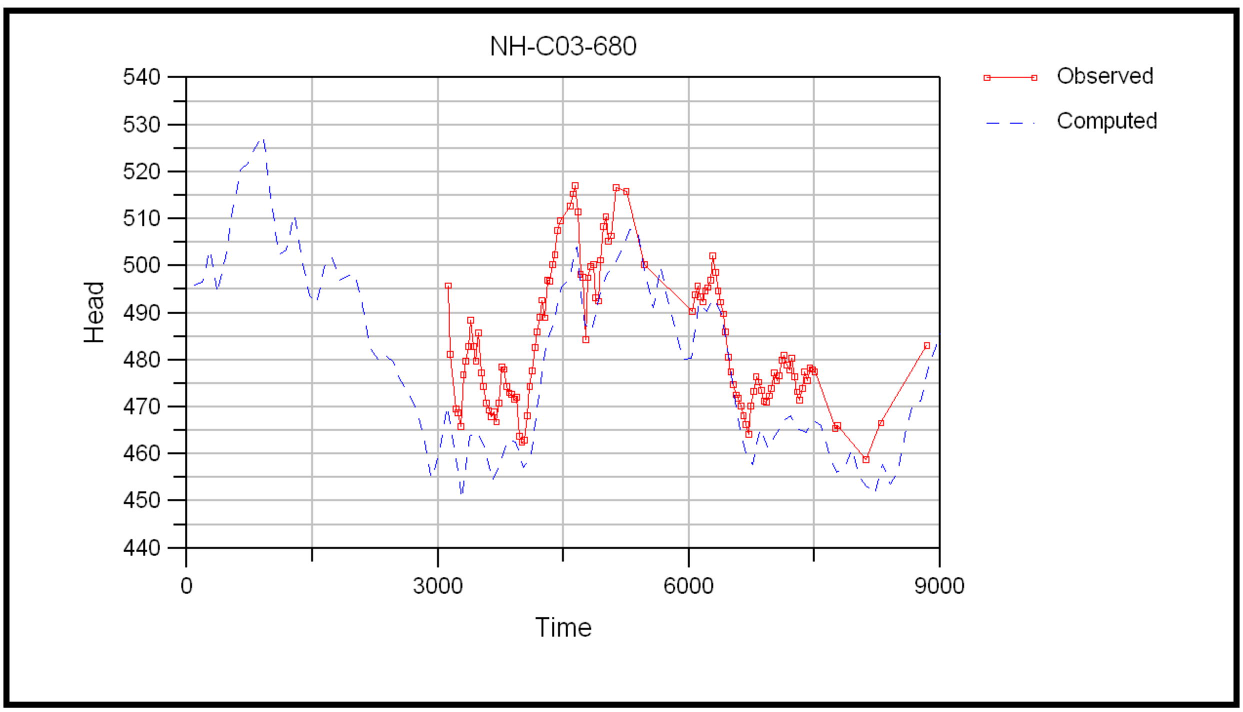
530
520
510
500
490
480
470
460
450
440
0
3000
6000
9000
Time



NH-C03-580
Observed
Computed
Head
Time
540
530
520
510
500
490
480
470
460
450
440
0
3000
6000
9000



NH-C03-680
Observed
Computed
Head
Time
540
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520
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460
450
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0
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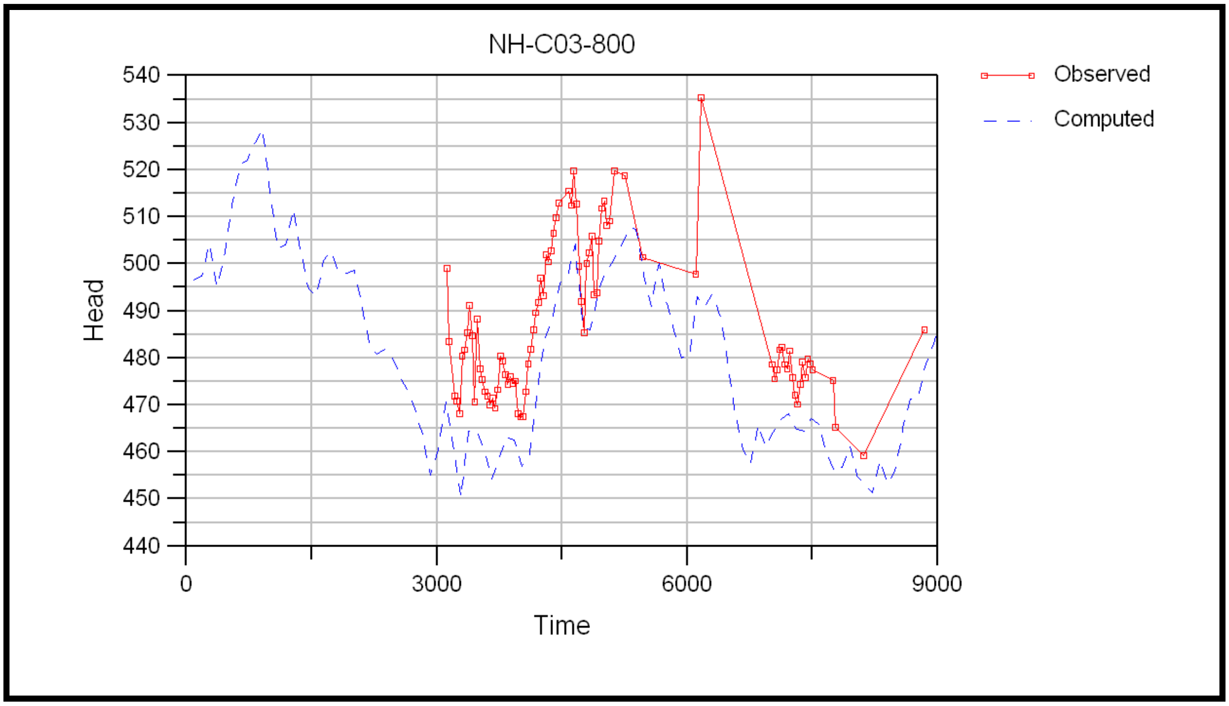
6000
9000


NH-C03-800
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Computed
Head
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500
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480
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450
440
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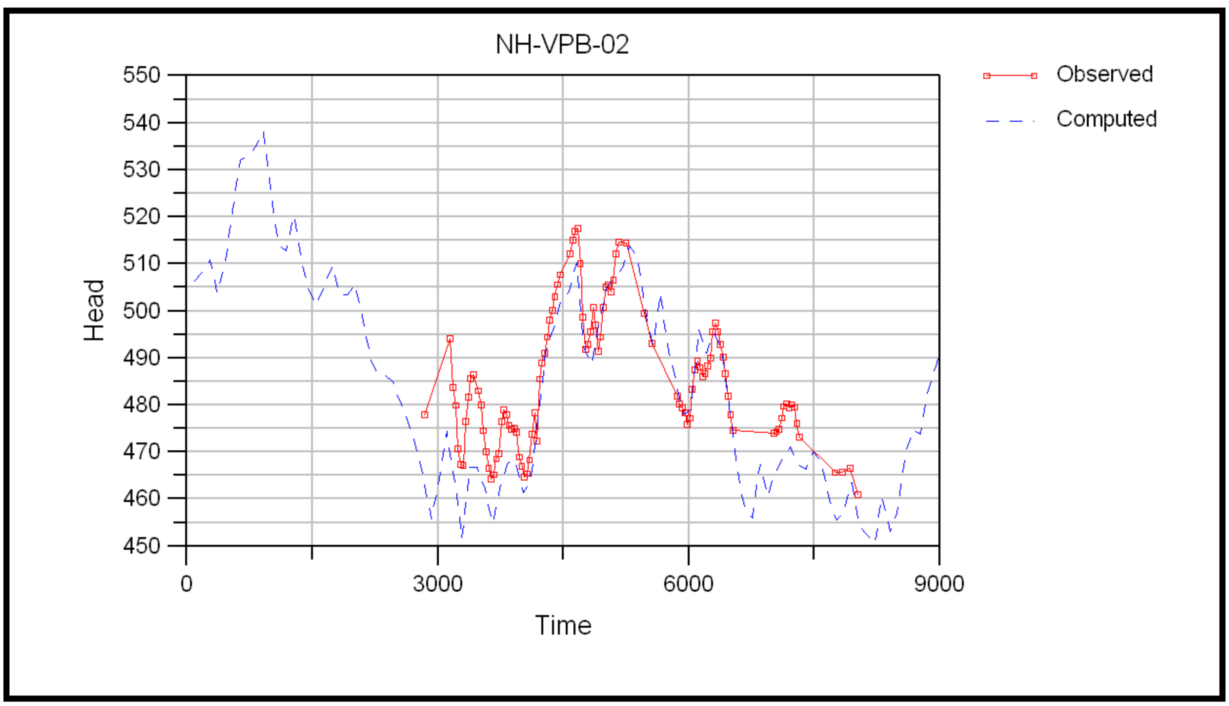
3000
6000
9000
Time


NH-VPB-02
Observed
Computed
Head
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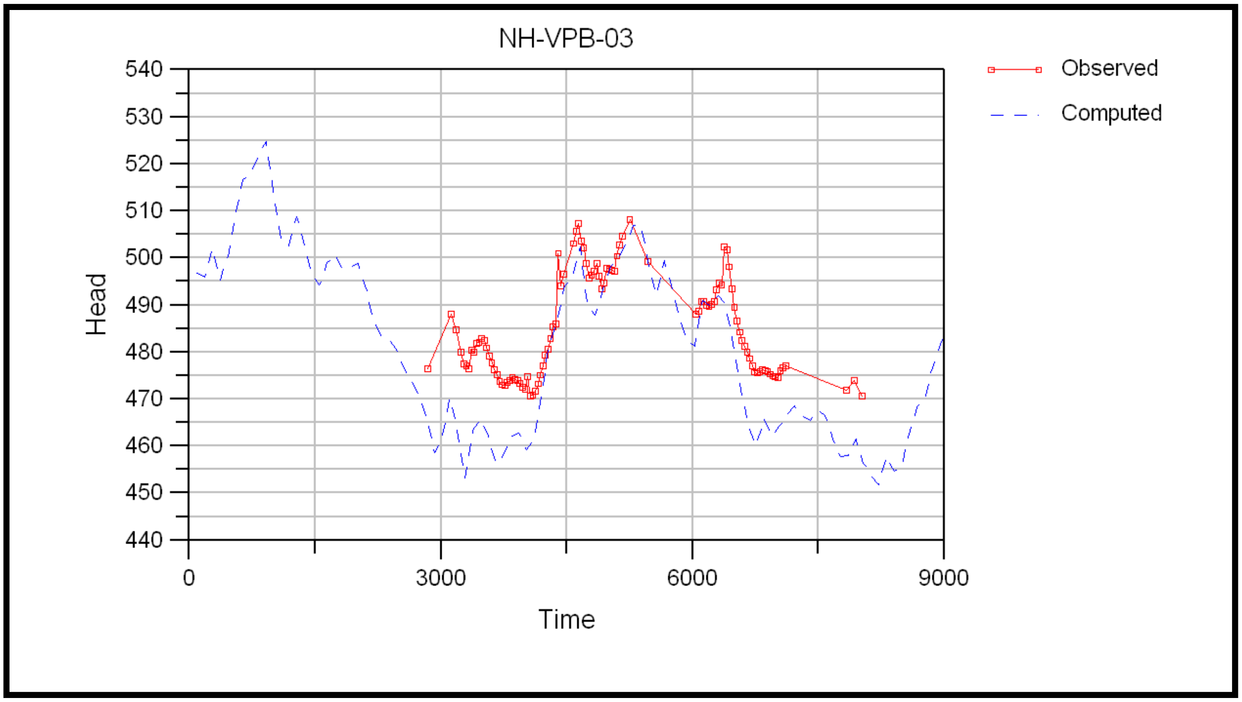
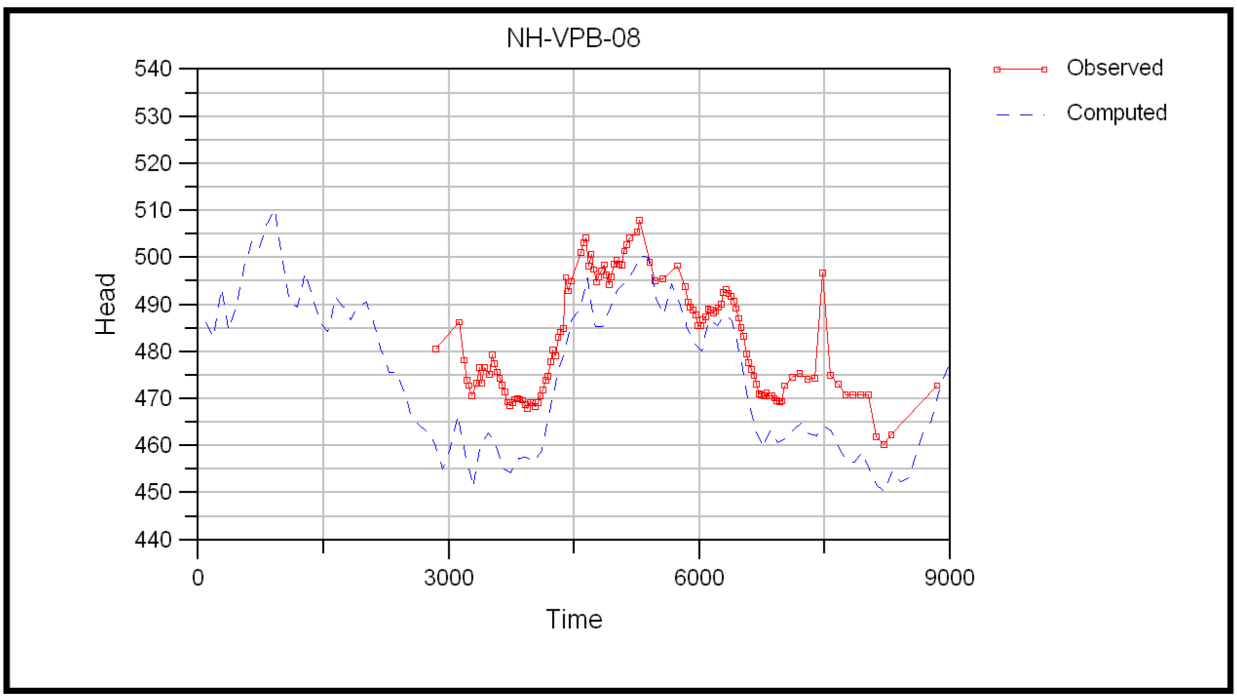
510
500
490
480
470
460
450
0
3000
6000
9000
Time



NH-VPB-03
Observed
Computed
Head
540
530
520
510
500
490
480
470
460
450
440
0
3000
6000
9000
Time



NH-VPB-08
Observed
Computed
Head
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530
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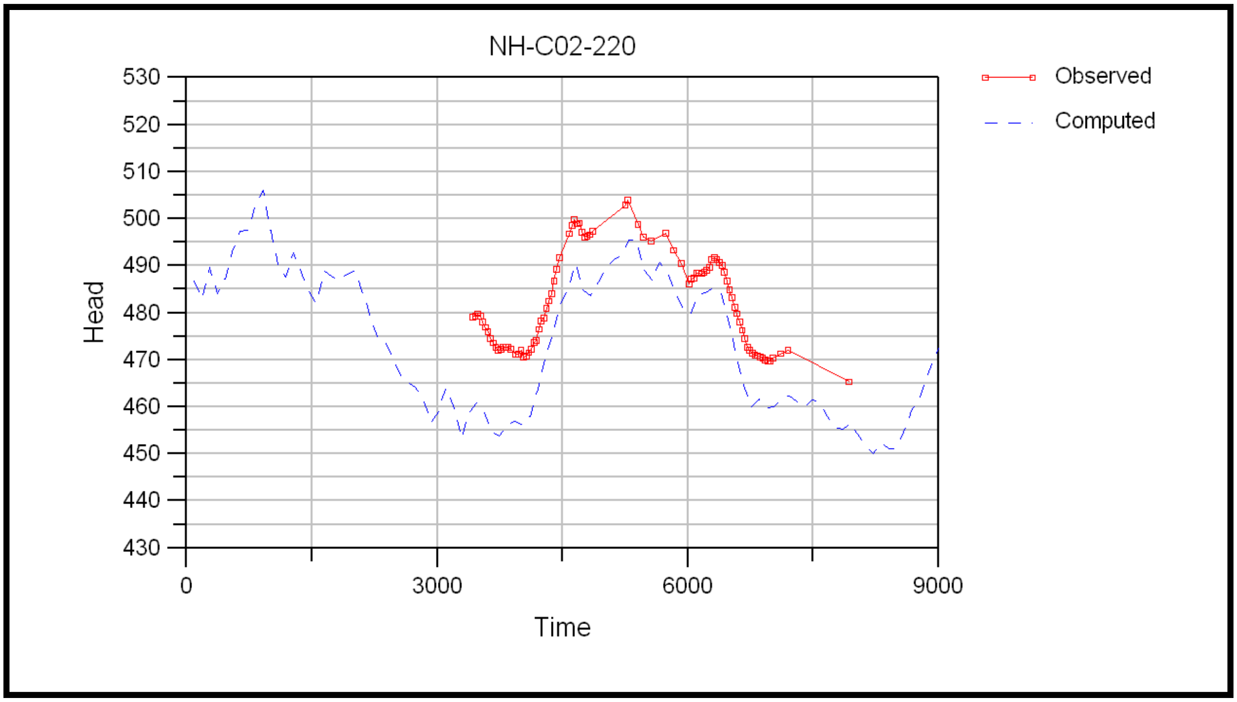
510
500
490
480
470
460
450
440
0
3000
6000
9000
Time



NH-C02-220
Observed
Computed
Head
Time
530
520
510
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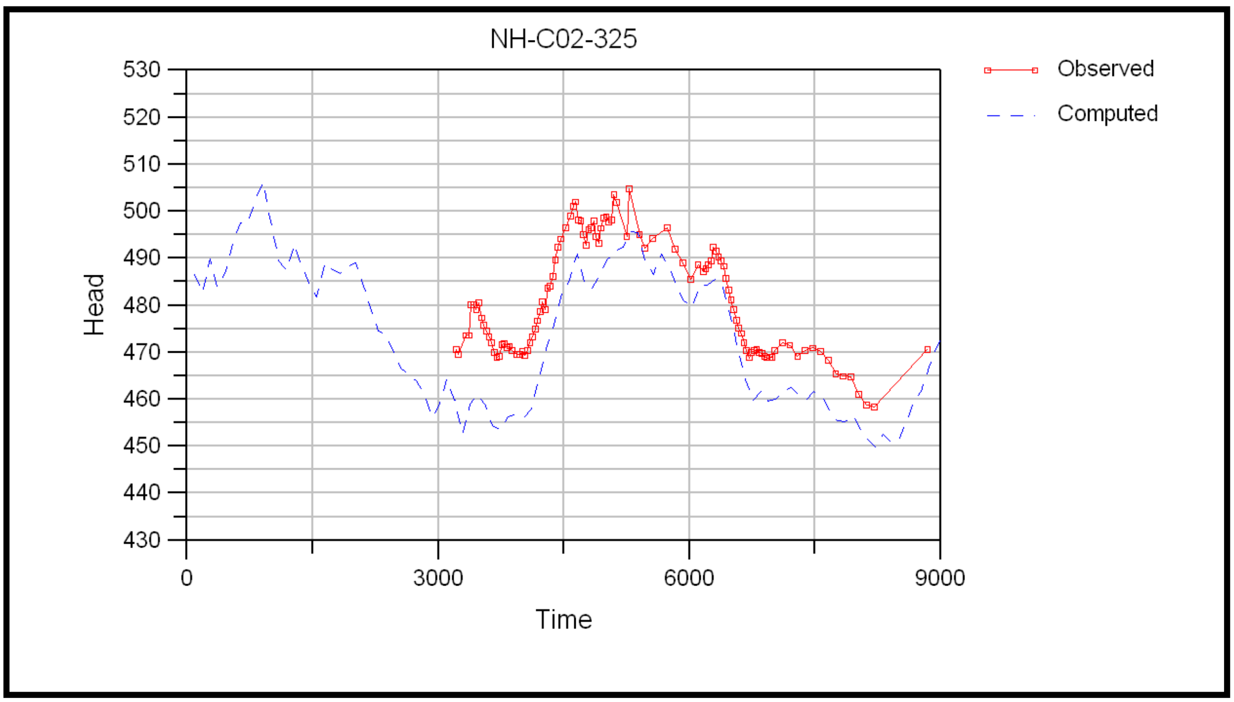
490
480
470
460
450
440
430
0
3000
6000
9000



NH-C02-325
Observed
Computed
Head
Time
530
520
510
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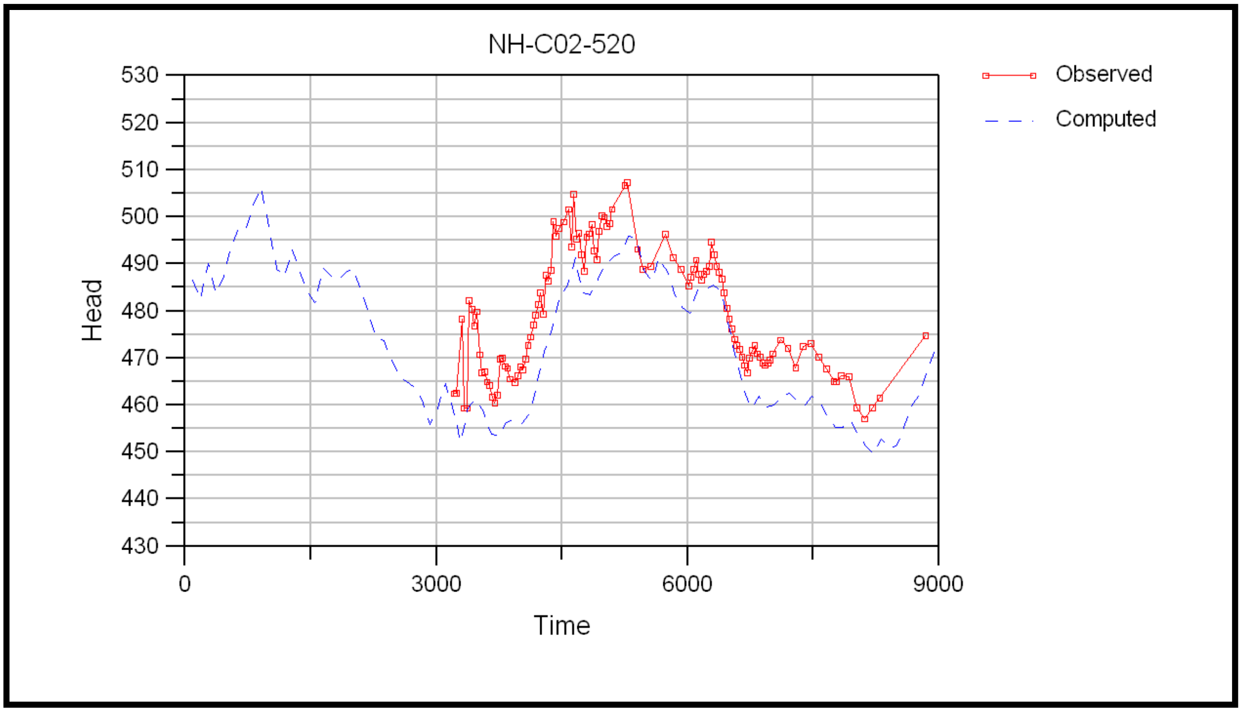
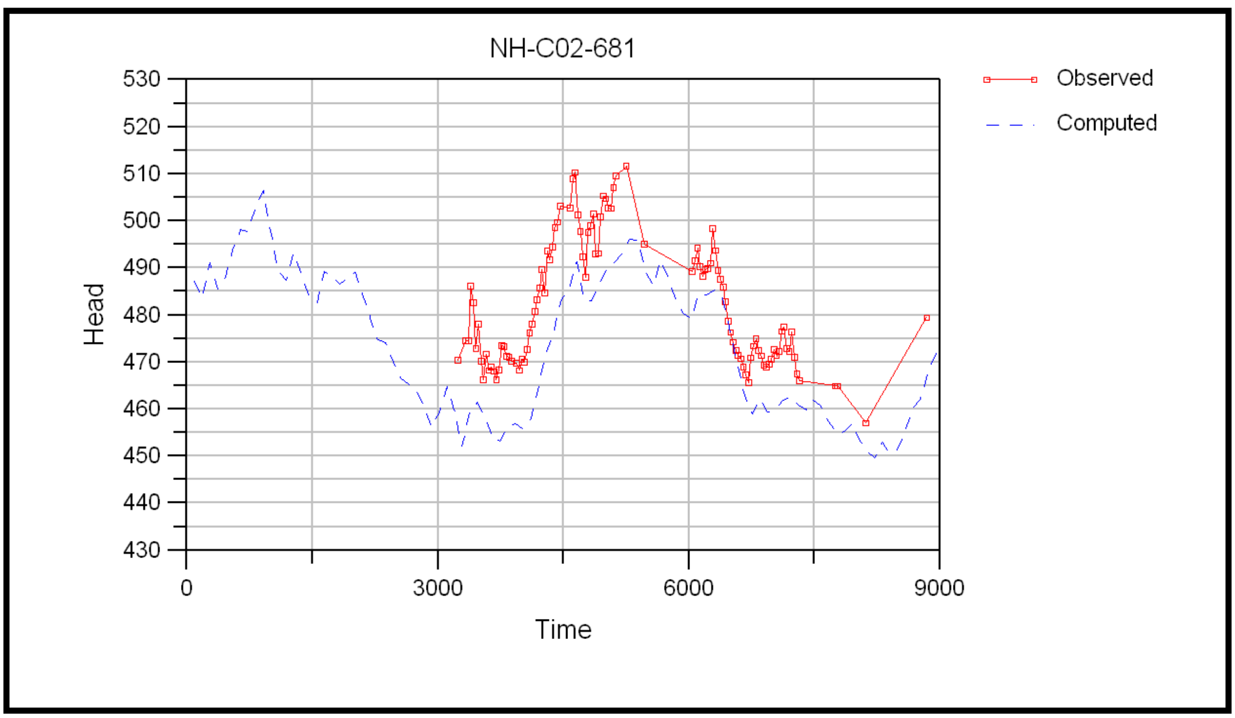
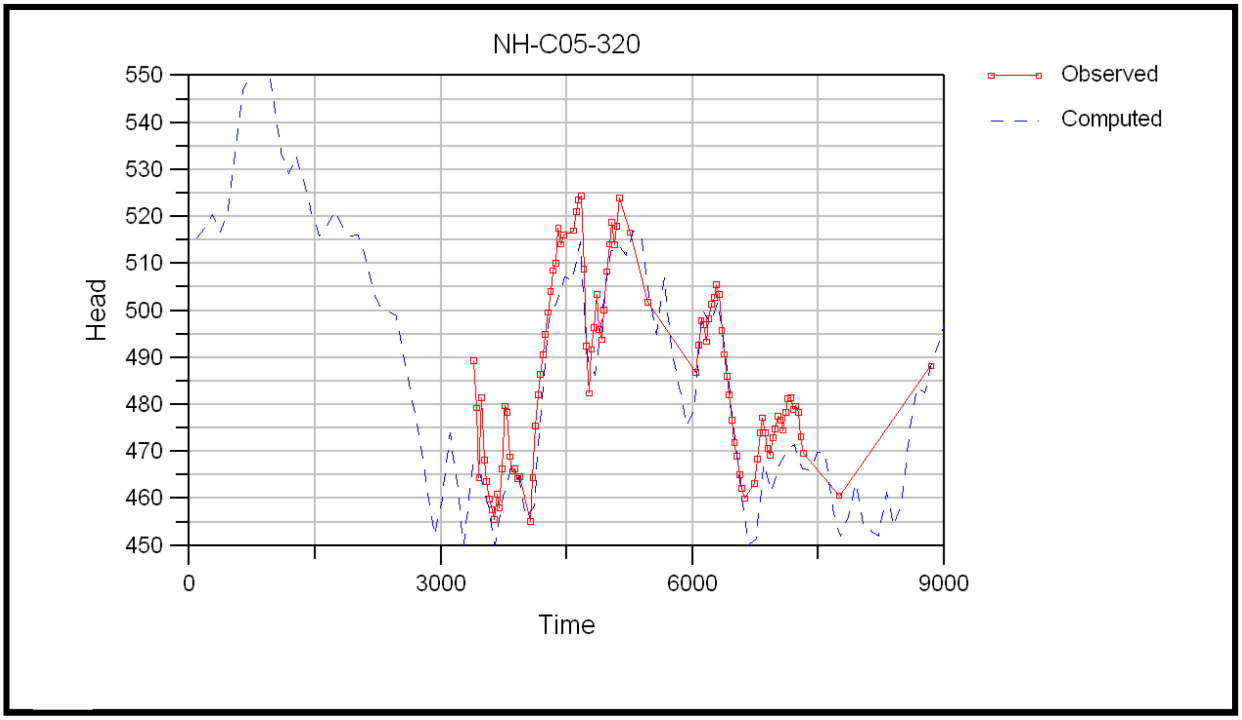
490
480
470
460
450
440
430
0
3000
6000
9000



NH-C02-520
Observed
Computed
Head
Time
530
520
510
500
490
480
470
460
450
440
430
0
3000
6000
9000



NH-C02-681
Observed
Computed
Head
Time
530
520
510
500
490
480
470
460
450
440
430
0
3000
6000
9000


NH-C05-320
Observed
Computed
Head
Time
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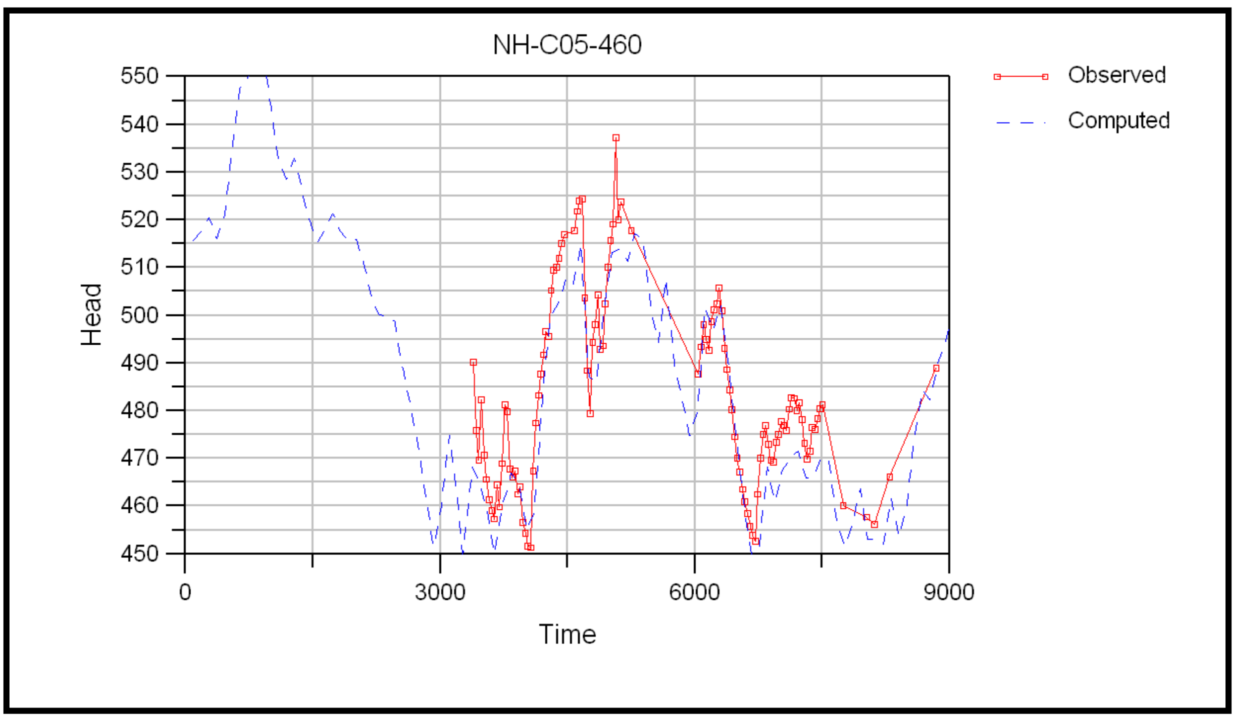
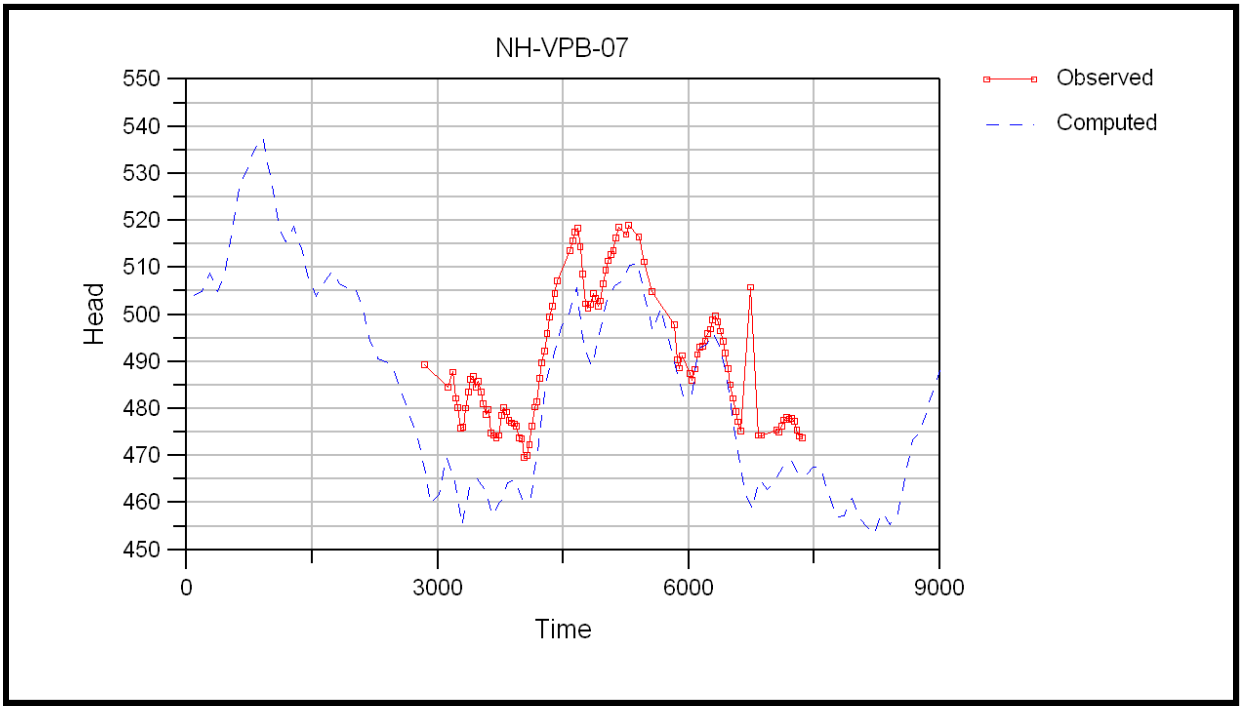
540
530
520
510
500
490
480
470
460
450
0
3000
6000
9000


NH-C05-460
Observed
Computed
Head
Time
550
540
530
520
510
500
490
480
470
460
450
0
3000
6000
9000



NH-VPB-07
Observed
Computed
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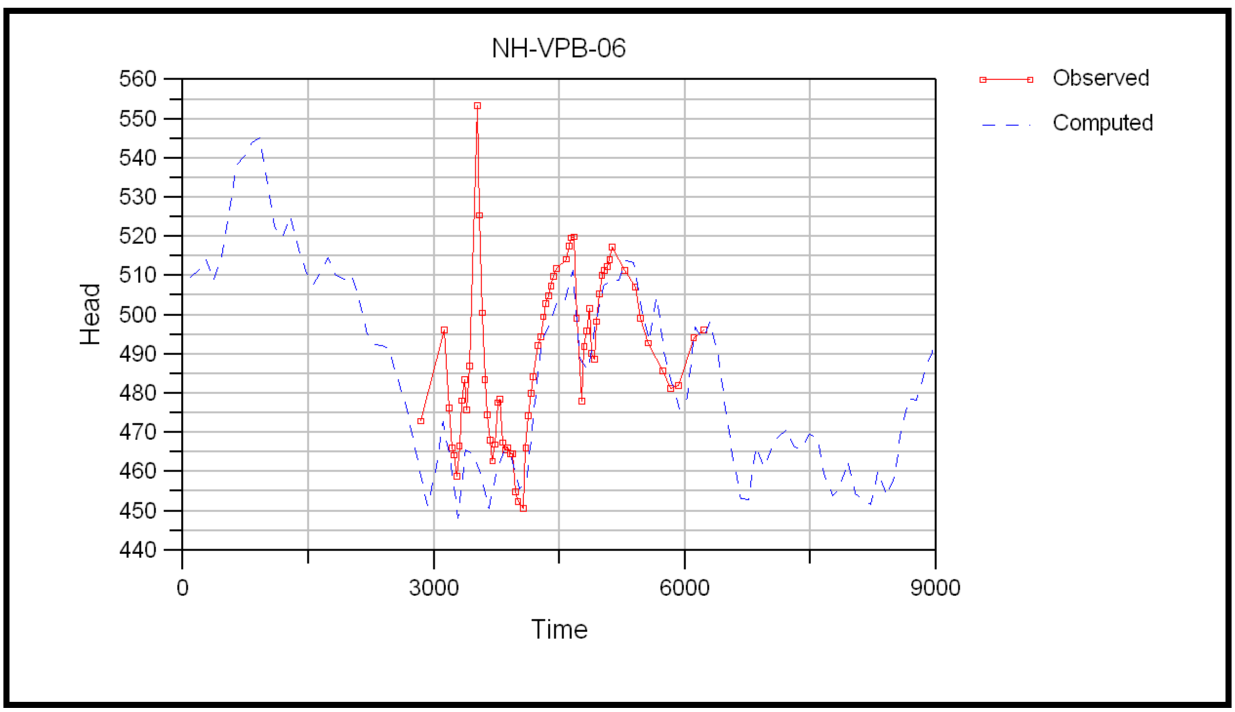
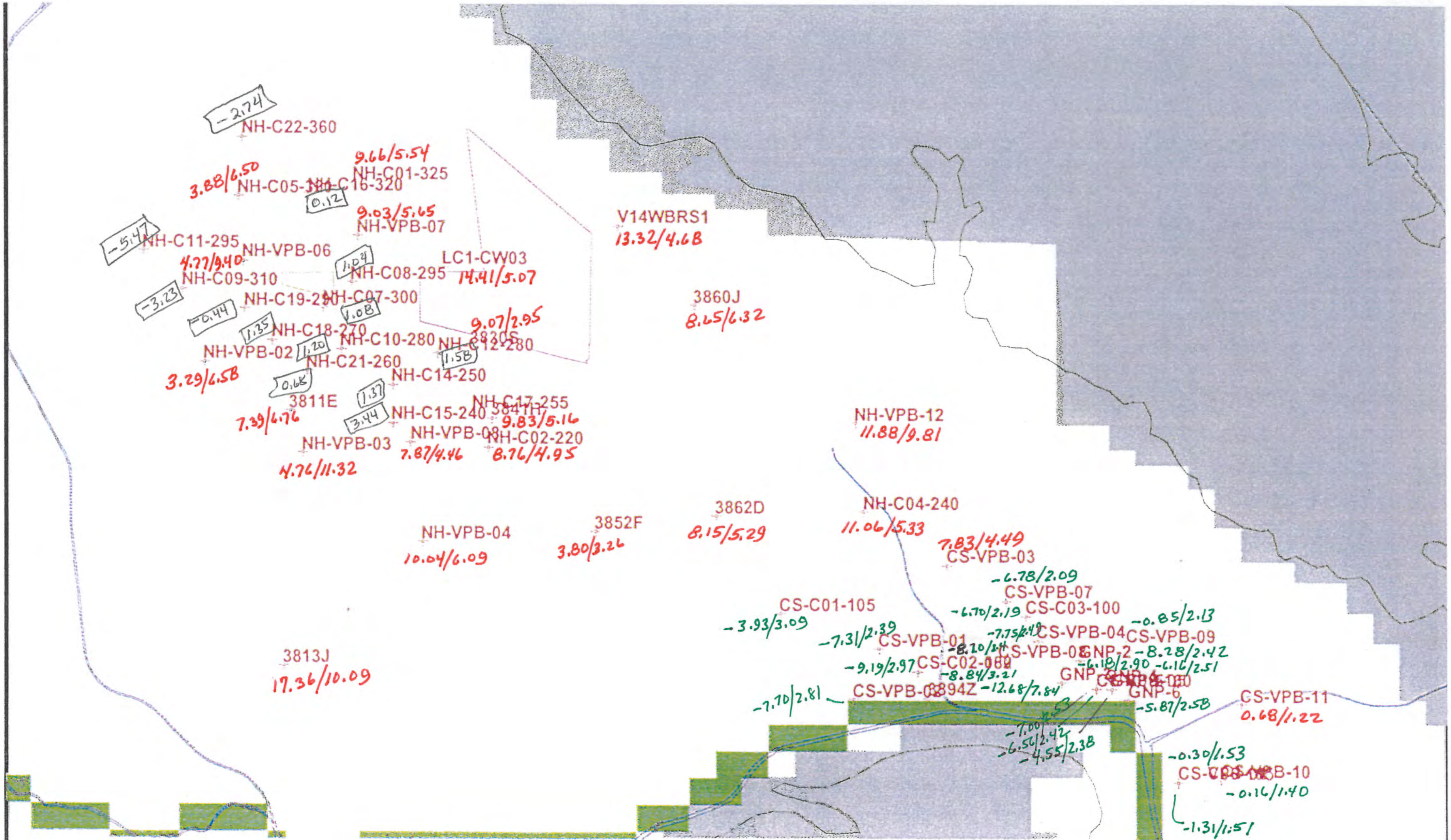
540
530
520
510
500
490
480
470
460
450
Head
0
3000
6000
9000
Time



NH-VPB-06
Observed
Computed
560
550
540
530
520
510
500
490
480
470
460
450
440
Head
0
3000
6000
9000
Time

ATTACHMENT 3

Plots of Residual Measures by Model Layer



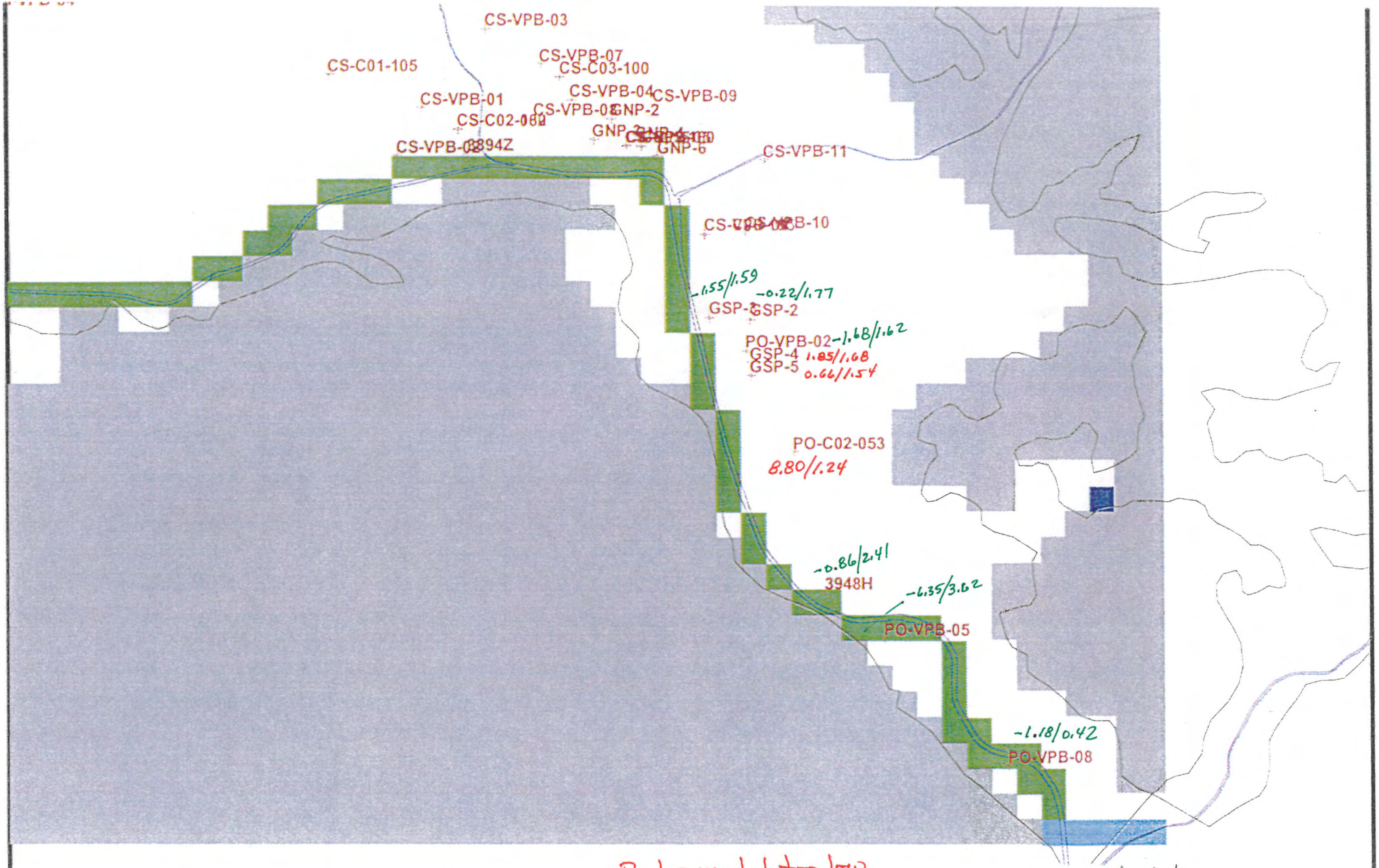
MODEL LAYER 1

Red = model too low

Green = model too high

= only one data point

Average/std dev



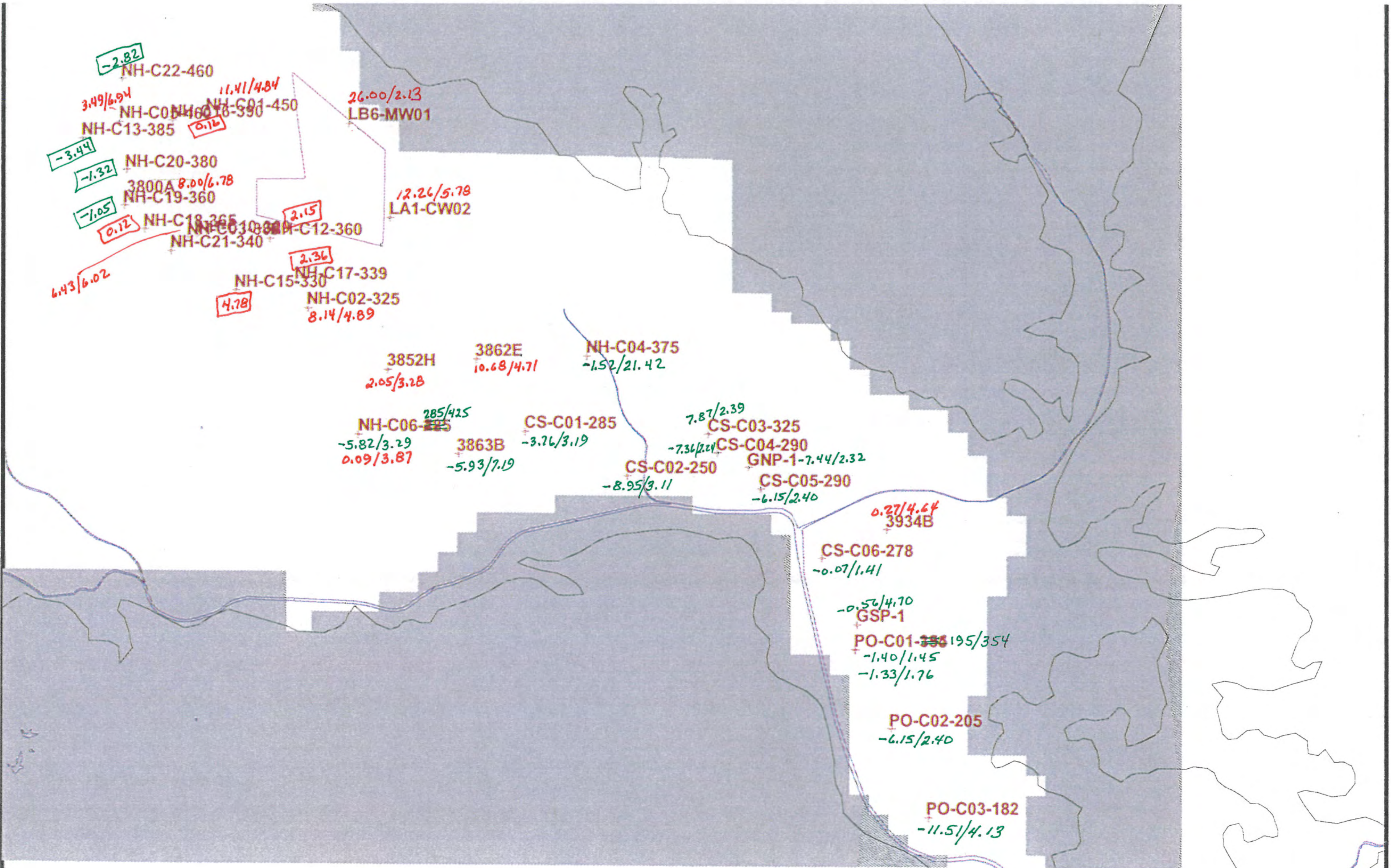
MODEL LAYER 1

Red = model too low

Green = model too high

▭ = only one data point

Average/std dev



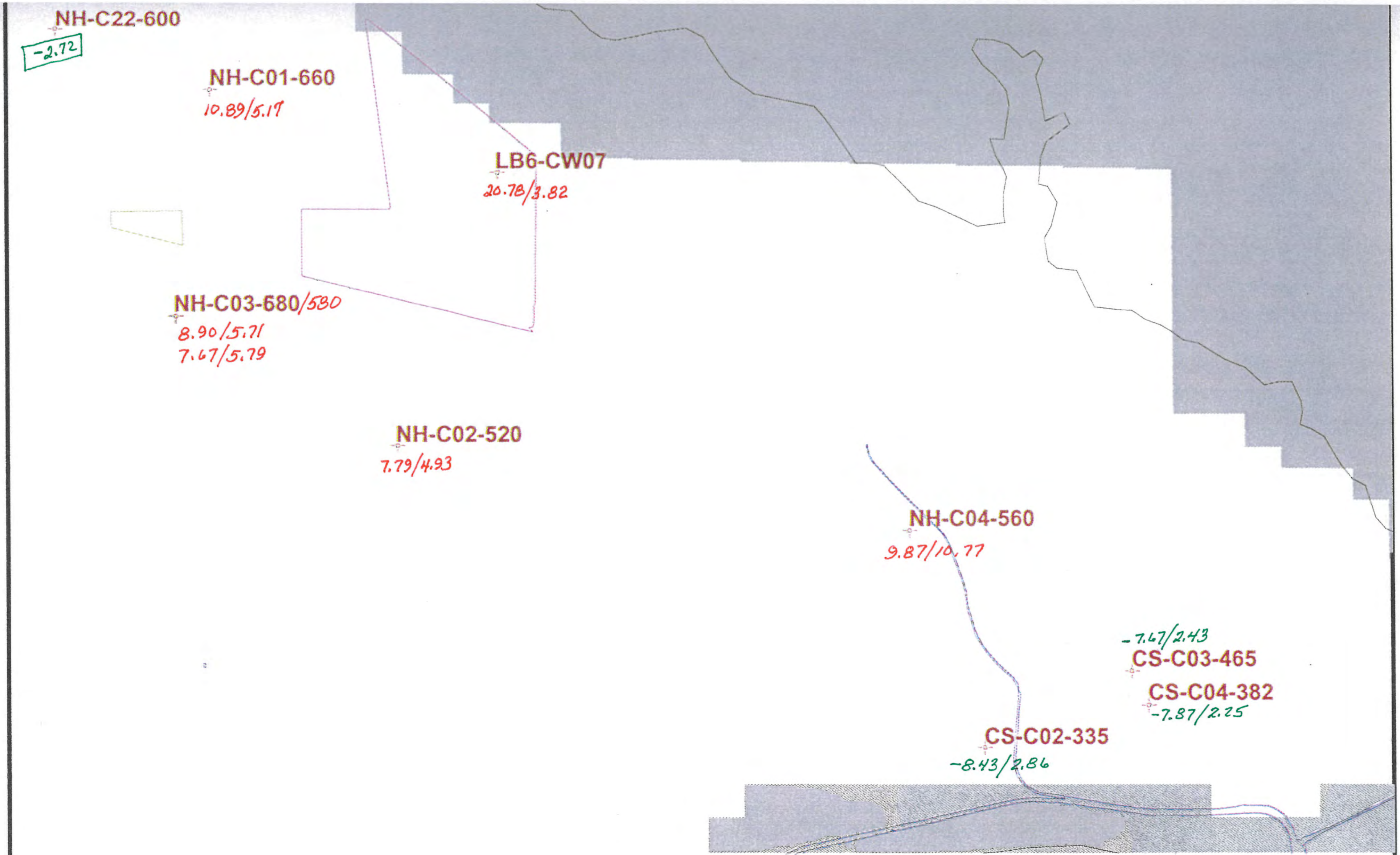
MODEL LAYER 2

Red = Model too low

Green = Model too high

☐ = new well, only one data point

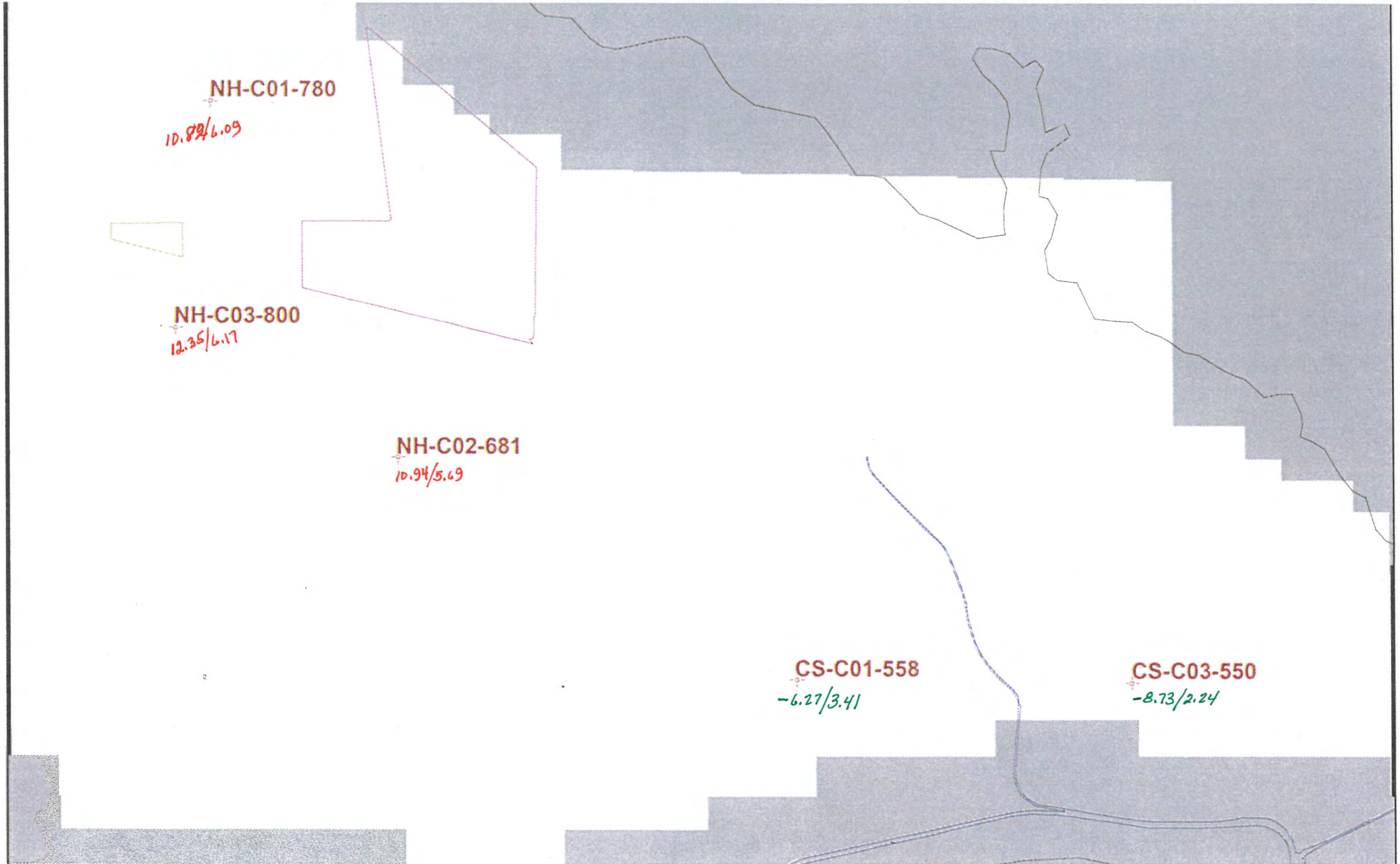
Average/Std dev



MODEL LAYER 3

Red = model too low
Green = model too high
☐ = only one data point

Average/std dev.



MODEL LAYER 4

Red = model too low
Green = model too high
▭ = only one data point

Average/std dev

ATTACHMENT 4

Estimates for Simulations of Future Conditions – FFS Modeling of Remedial Alternatives

SDMS DOCID# 1117518

Attachment 1

Table 1

Simulated Hydrologic Cycle for Assumed Extractions in San Fernando Basin during Normal, Wet, and Dry Years

				LADWP									BURBANK			GLENDALE				OTHERS				
		Rain Precipitation (IN)	Water Years	NHOU	ERWIN	NORTH HOLLY WOOD - WEST BRANCH	POLLOCK	RINALDI-TOLUCA	TUJUNGA	VERDUGO	WHITNALL	TOTAL LADWP (AF/Y)	CITY OF BURBANK	LOCKHEED	TOTAL BURBANK (AF/Y)	CITY OF GLENDALE	OU-NORTH	OU-SOUTH	TOTAL GLENDALE (AF/Y)	TOTAL NON LADWP (AF/Y)	TOTAL NON GLENDALE (F. LAWN) (AF/Y)	NON-BURBANK (VMP) (AF/Y)	SAN FERNANDO BASIN TOTAL EXTRACTION (AF/Y)	REMARK
		14	2005-06	1,645	1,744	10,031	2,303	11,375	7,637	792	1,789	37,316	0	10,624	10,624	360	4,517	2,349	7,225	1,494	400	400	57,059	Actual and Projected Pumping for the last month
No.	Historical Hydrologic Cycle Water Years	Historical Rain Precipitation (IN)	Simulated Future Water Years	NHOU	ERWIN	NORTH HOLLY WOOD - WEST BRANCH	POLLOCK	RINALDI-TOLUCA	TUJUNGA	VERDUGO	WHITNALL	TOTAL LADWP (AF/Y)	CITY OF BURBANK	LOCKHEED	TOTAL BURBANK (AF/Y)	CITY OF GLENDALE	OU-NORTH	OU-SOUTH	TOTAL GLENDALE (AF/Y)	TOTAL NON LADWP (AF/Y)	TOTAL NON GLENDALE (F. LAWN) (AF/Y)	NON-BURBANK (VMP) (AF/Y)	SAN FERNANDO BASIN TOTAL EXTRACTION (AF/Y)	REMARK
1	2003-04	9.5	2006-07	4,437	2,886	26,175	2,000	41,668	36,729	4,905	4,407	123,207	0	10,162	10,162	25	5,184	2,016	7,225	1,494	400	300	142,488	Assumed Pumping
2	2002-03	19.41	2007-08	4,437	2,886	22,408	2,000	25,197	22,413	4,905	2,754	87,000	0	11,000	11,000	25	5,184	2,016	7,225	1,494	400	300	107,119	Assumed Pumping
3	2001-02	5.95	2008-09	4,437	2,886	26,175	2,000	41,668	36,729	4,905	4,407	123,207	0	11,000	11,000	25	5,184	2,016	7,225	1,494	400	300	143,326	Assumed Pumping
4	2000-01	19.52	2009-10	4,437	2,886	22,408	2,000	25,197	22,413	4,905	2,754	87,000	0	11,000	11,000	25	5,184	2,016	7,225	1,494	400	300	107,119	Assumed Pumping
5	1999-00	14.84	2010-11	4,437	2,886	26,175	2,000	41,668	36,729	4,905	4,407	123,207	0	11,000	11,000	25	5,184	2,016	7,225	1,494	400	300	143,326	Assumed Pumping
6	1998-99	9.81	2011-12	4,437	2,886	26,175	2,000	41,668	36,729	4,905	4,407	123,207	0	11,000	11,000	25	5,184	2,016	7,225	1,494	400	300	143,326	Assumed Pumping
7	1997-98	37.04	2012-13	4,437	2,886	22,408	2,000	25,197	22,413	4,905	2,754	87,000	0	11,000	11,000	25	5,184	2,016	7,225	1,494	400	300	107,119	Assumed Pumping
8	1996-97	15.17	2013-14	4,437	2,886	26,175	2,000	41,668	36,729	4,905	4,407	123,207	0	11,000	11,000	25	5,184	2,016	7,225	1,494	400	300	143,326	Assumed Pumping
9	1995-96	12.03	2014-15	4,437	2,886	26,175	2,000	41,668	36,729	4,905	4,407	123,207	0	11,000	11,000	25	5,184	2,016	7,225	1,494	400	300	143,326	Assumed Pumping
10	1994-95	32.7	2015-16	4,437	2,886	22,408	2,000	25,197	22,413	4,905	2,754	87,000	0	11,000	11,000	25	5,184	2,016	7,225	1,494	400	300	107,119	Assumed Pumping
11	1993-94	10.19	2016-17	4,437	2,886	26,175	2,000	41,668	36,729	4,905	4,407	123,207	0	11,000	11,000	25	5,184	2,016	7,225	1,494	400	300	143,326	Assumed Pumping

Model Input Assumptions:

1- During normal and wet years assumed to pump 87,000 AF/Y (LADWP's Annual Water Right) from LADWP's eight well fields that includes the NHOU wells.
2- During dry years assumed to pump 123,207 AF/Y (W-Y 1998-99 LADWP Production) from LADWP's eight well fields that includes NHOU wells.
3- NHOU assumed to pump initially 3,000 gpm. Other flowrates should be evaluted to maximize the capture zone of containment for NHOU.
4-Extractions from the Cities of Burbank and Glendale are the projected pumping by the two cities for future operations.
5- Extraction by others:
Non-LADWP is mostly that extracted by Calmat from Well Nos. 4916A, 4916, and 4916(x).
Non-Glendale is extractions by Forest Lawn Memorial Park from Well Nos. 3947A, 3947B, 3947C, 3858K, and 3947M.
Non-Burbank is extractions by Valhalla Memorial Park (VMP) from Well No. 3840K.

Attachment 1 (con't.)

Table 2

PROJECTED PERCENTAGE EXTRACTION FROM LADWP ACTIVE WELLS

NORTH HOLLYWOOD-WEST BRANCH		%
NH-4 (WB)	2.5 cfs	**4.10%**
NH-7 (WB)	0.9 cfs	**1.48%**
NH-22 (WB)	4.7 cfs	**7.70%**
NH-23 (WB)	5.3 cfs	**8.69%**
NH-25 (WB)	3.5 cfs	**5.74%**
NH-26 (WB)	3.7 cfs	**6.07%**
NH-32 (WB)	2.9 cfs	**4.75%**
NH-33 (WB)	3.9 cfs	**6.39%**
NH-34 (WB)	6.5 cfs	**10.66%**
NH-36 (WB)	4.4 cfs	**7.21%**
NH-37 (WB)	4.2 cfs	**6.89%**
NH-43a (WB)	5.7 cfs	**9.34%**
NH-44 (WB)	5.4 cfs	**8.85%**
NH-45 (WB)	7.4 cfs	**12.13%**
TOTAL	**61.0 cfs**	**100.00%**

RINALDI-TOLUCA		%
RT-1	6.8 cfs	**6.31%**
RT-2	6.9 cfs	**6.40%**
RT-3	7.9 cfs	**7.33%**
RT-4	7.0 cfs	**6.49%**
RT-5	7.5 cfs	**6.96%**
RT-6	6.7 cfs	**6.22%**
RT-7	7.3 cfs	**6.77%**
RT-8	5.0 cfs	**4.64%**
RT-9	7.8 cfs	**7.24%**
RT-10	8.1 cfs	**7.51%**
RT-11	7.4 cfs	**6.86%**
RT-12	8.3 cfs	**7.70%**
RT-13	7.4 cfs	**6.86%**
RT-14	7.0 cfs	**6.49%**
RT-15	6.7 cfs	**6.22%**
TOTAL	**107.8 cfs**	**100.00%**

TUJUNGA		%
TJ-1	9.1 cfs	**8.59%**
TJ-2	8.0 cfs	**7.55%**
TJ-3	9.5 cfs	**8.97%**
TJ-4	8.5 cfs	**8.03%**
TJ-5	8.8 cfs	**8.31%**
TJ-6	8.3 cfs	**7.84%**
TJ-7	8.5 cfs	**8.03%**
TJ-8	9.0 cfs	**8.50%**
TJ-9	9.3 cfs	**8.78%**
TJ-10	9.0 cfs	**8.50%**
TJ-11	8.4 cfs	**7.93%**
TJ-12	9.5 cfs	**8.97%**
TOTAL	**105.9 cfs**	**100.00%**

ERWIN		%
ER-6	3.0 cfs	***62.50%***
ER-10	1.8 cfs	***37.50%***
TOTAL	**4.8 cfs**	**100.00%**

WHITNALL		%
WH-4	7.5 cfs	**39.68%**
WH-5	4.8 cfs	**25.40%**
WH-6	4.3 cfs	**22.75%**
WH-7	2.3 cfs	**12.17%**
TOTAL	**18.9 cfs**	**100.00%**

VERDUGO		%
VE-11	*3.4 cfs*	***40.96%***
VE-24	4.9 cfs	***59.04%***
TOTAL	**8.3 cfs**	**100.00%**

POLLOCK		%
P-4	2.9 cfs	**50.00%**
P-6	2.9 cfs	**50.00%**
TOTAL	**5.8 cfs**	**100.00%**

Attachment 1 (con't.)

Table 3A

Simulated Hydrologic Cycle for Recharge in San Fernando Basin during Normal, Wet, and Dry Years

			BASIN RECHARGE (AF/Y)																		
			RAINFALL (IN/Y)		PERCOLATION			H&M	SPREADING GROUNDS							SUB-SURFACE INFLOW				
		Water Years	VALLEY	HILL & MTN	VALLEY FILL	DELIVERED WATER RETURN	SUB TOTAL	HILL & MTN	BRANFORD	HANSEN	HEADWORKS	LOPEZ	PACOIMA	TUJUNGA	SUB - TOTAL	PACOIMA NOTCH	SYLMAR NOTCH	VERDUGO BASIN	SUB - TOTAL	TOTAL RECHARGE
		2005-06	14	16.70	9,726	53,178	62,904	2,852	519	19,390	-	911	7,350	10,759	38,929	350	400	70	820	105,505
No.	Historical Hydrologic Cycle Water years	Simulated Future Water Years	VALLEY	HILL & MTN	VALLEY FILL	DELIVERED WATER RETURN	SUB TOTAL	HILL & MTN	BRANFORD	HANSEN	HEADWORKS	LOPEZ	PACOIMA	TUJUNGA	SUB - TOTAL	PACOIMA NOTCH	SYLMAR NOTCH	VERDUGO BASIN	SUB - TOTAL	TOTAL RECHARGE
1	2003-04	2006-07	9.5	13.00	6,600	53,521	60,121	2,220	444	6,424	-	144	1,731	1,322	10,065	350	400	70	820	73,226
2	2002-03	2007-08	19.41	22.40	13,484	56,256	69,740	3,826	932	9,427	-	518	3,539	1,914	16,330	350	400	70	820	90,716
3	2001-02	2008-09	5.95	7.10	4,133	54,825	58,958	1,213	460	1,342	-	-	761	101	2,664	350	400	70	820	63,655
4	2000-01	2009-10	19.52	25.10	13,561	58,007	71,568	4,287	562	11,694	-	172	3,826	1,685	17,939	350	400	70	820	94,614
5	1999-00	2010-11	14.84	18.70	10,309	52,904	63,213	3,194	468	7,487	-	578	2,909	2,664	14,106	350	400	70	820	81,333
6	1998-99	2011-12	9.81	11.53	6,815	49,368	56,183	1,969	547	8,949	-	536	696	3,934	14,662	350	400	70	820	73,634
7	1997-98	2012-13	37.04	38.51	25,732	55,072	80,804	6,577	641	28,129	-	378	20,714	11,180	61,042	350	400	70	820	149,243
8	1996-97	2013-14	15.17	17.65	10,539	53,750	64,289	3,015	415	9,808	-	724	5,768	6,406	23,121	350	400	70	820	91,244
9	1995-96	2014-15	12.03	16.02	8,357	49,233	57,590	2,736	345	8,232	-	363	4,532	7,767	21,239	350	400	70	820	82,385
10	1994-95	2015-16	32.7	33.40	22,717	64,709	87,426	5,705	585	35,137	-	1,086	14,064	18,236	69,108	350	400	70	820	163,058
11	1993-94	2016-17	10.19	12.89	7,079	52,974	60,053	2,202	462	12,052	-	182	3,156	4,129	19,981	350	400	70	820	83,056

Attachment 1 (con't.)

Table 3B

Simulated Hydrologic Cycle for Recharge in San Fernando Basin during Normal, Wet, and Dry Years

			RAINFALL (IN/Y)		BASIN RECHARGE (AF/Y)																
					PERCOLATION			H&M	SPREADING GROUNDS								SUB-SURFACE INFLOW				
		Water Years	VALLEY	HILL & MTN	VALLEY FILL	DELIVERED WATER RETURN	SUB TOTAL	HILL & MTN	BRANFORD	HANSEN	HEADWORKS	LOPEZ	PACOIMA		TUJUNGA	SUB - TOTAL	PACOIMA NOTCH	SYLMAR NOTCH	VERDUGO BASIN	SUB - TOTAL	TOTAL RECHARGE
		2005-06	14	16.70	9,726	53,178	62,904	2,852	519	19,390	-	911	7,350		10,759	38,929	350	400	70	820	105,505
No.	Historical Hydrologic Cycle Water years	Simulated Future Water Years	VALLEY	HILL & MTN	VALLEY FILL	DELIVERED WATER RETURN	SUB TOTAL	HILL & MTN	BRANFORD	HANSEN	HEADWORKS	LOPEZ	PACOIMA	PROJECTED BURBANK RECHARGE AT PACOIMA	TUJUNGA	SUB - TOTAL	PACOIMA NOTCH	SYLMAR NOTCH	VERDUGO BASIN	SUB - TOTAL	TOTAL RECHARGE
1	2003-04	2006-07	9.5	13.00	6,600	53,521	60,121	2,220	444	6,424	-	144	1,731		1,322	10,065	350	400	70	820	73,226
2	2002-03	2007-08	19.41	22.40	13,484	56,256	69,740	3,826	932	9,427	-	518	3,539	3,850	1,914	20,180	350	400	70	820	94,566
3	2001-02	2008-09	5.95	7.10	4,133	54,825	58,958	1,213	460	1,342	-	-	761	5,050	101	7,714	350	400	70	820	68,705
4	2000-01	2009-10	19.52	25.10	13,561	58,007	71,568	4,287	562	11,694	-	172	3,826	6,000	1,685	23,939	350	400	70	820	100,614
5	1999-00	2010-11	14.84	18.70	10,309	52,904	63,213	3,194	468	7,487	-	578	2,909	6,200	2,664	20,306	350	400	70	820	87,533
6	1998-99	2011-12	9.81	11.53	6,815	49,368	56,183	1,969	547	8,949	-	536	696	6,200	3,934	20,862	350	400	70	820	79,834
7	1997-98	2012-13	37.04	38.51	25,732	55,072	80,804	6,577	641	28,129	-	378	20,714	6,200	11,180	67,242	350	400	70	820	155,443
8	1996-97	2013-14	15.17	17.65	10,539	53,750	64,289	3,015	415	9,808	-	724	5,768	6,200	6,406	29,321	350	400	70	820	97,444
9	1995-96	2014-15	12.03	16.02	8,357	49,233	57,590	2,736	345	8,232	-	363	4,532	6,200	7,767	27,439	350	400	70	820	88,585
10	1994-95	2015-16	32.7	33.40	22,717	64,709	87,426	5,705	585	35,137	-	1,086	14,064	6,200	18,236	75,308	350	400	70	820	169,258
11	1993-94	2016-17	10.19	12.89	7,079	52,974	60,053	2,202	462	12,052	-	182	3,156	6,200	4,129	26,181	350	400	70	820	89,256

ATTACHMENT 5

Projected Groundwater use for Water Years 2010-2015 – Expected from the 2011 Annual ULARA Watermaster Pumping Spreading Plan

Table 7-1
MODEL INPUT
San Fernando Basin Recharge & Extractions
2010-2015

Table 7-1A
Projected San Fernando Basin Recharge 2010-15

WATER YEAR	RAINFALL (IN/Y)		SAN FERNANDO BASIN RECHARGE (AF/Y)																
			PERCOLATION			H&M (A)	SPREADING GROUNDS								SUBSURFACE INFLOW				TOTAL RECHARGE
										PACOIMA									
	VALLEY	HILL & MTN	VALLEY FILL	RETURN WATER	SUB TOTAL	HILL & MTN	BRANFORD	HANSEN (B) (NATIVE)	LOPEZ	PACOIMA (NATIVE)	PACOIMA (C) (MWD)	PACOIMA (TOTAL)	TUJUNGA (D)	SUB-TOTAL	PACOIMA NOTCH	SYLMAR NOTCH	VERDUGO BASIN	SUB-TOTAL	
2010-11	23.00	26.00	15,978	49,975	65,953	4,440	892	21,945	2,398	21,066	6,200	27,266	37,514	90,015	350	400	70	820	161,228
2010-12	18.07	22.47	12,553	54,347	66,900	3,838	540	11,000	540	6,564	6,200	12,764	7,534	32,378	350	400	70	820	103,936
2010-13	18.07	22.47	12,553	54,347	66,900	3,838	540	18,534	540	6,564	6,200	12,764	0	32,378	350	400	70	820	103,936
2010-14	18.07	22.47	12,553	54,347	66,900	3,838	540	18,534	540	6,564	6,200	12,764	0	32,378	350	400	70	820	103,936
2010-15	18.07	22.47	12,553	54,347	66,900	3,838	540	11,000	540	6,564	6,200	12,764	7,534	32,378	350	400	70	820	103,936

Table 7-1B
Projected San Fernando Basin Pumping

WATER YEAR	SAN FERNANDO BASIN EXTRACTIONS (AF/Y)																			
	LADWP											BURBANK			GLENDALE			OTHERS		
	AE	ER	HW	NH (WEST)	NH (EAST)	PL	RT	TJ	VD	WH	TOTAL LADWP (E)	BURBANK PSD	LOCKHEED	NON-BURBANK (VMP)	CITY OF GLENDALE	GL-NORTH	GL-SOUTH	TOTAL NON-LADWP	TOTAL NON-GLENDALE (F. LAWN)	TOTAL EXTRACTION
2010-11	-1,008	-1,373	0	-5,845	0	-3,553	-6,892	-20,663	-1,760	-2,724	-43,818		-10,097	-300	-20	-4,745	-2,555	-628	-400	-62,563
2010-12	-1,937	0	0	-4,367	0	-2,178	-6,550	-15,674	-2,687	-8,607	-42,000	0	-11,026	0	-20	-4,745	-2,555	-628	-400	-61,374
2010-13	-1,937	0	0	-2,967	0	-2,178	-4,451	-15,674	-2,687	-5,106	-35,000	0	-11,026	0	-20	-4,745	-2,555	-628	-400	-54,374
2010-14	-1,937	0	0	-1,567	0	-2,178	-2,350	-15,674	-2,553	-1,741	-28,000	0	-11,026	0	-20	-4,745	-2,555	-628	-400	-47,374
2010-15	-1,937	0	0	-1,211	0	-2,178	0	-15,674	0	0	-21,000	0	-11,026	0	-20	-4,745	-2,555	-628	-400	-40,374

NOTES:

(A) Hill & Mountain runoff

(B) Hansen Spreading Grounds activated in the water year of 2009-10 after completing the modification work

(C) Burbank projected to spread a total of 6,200 AF of imported water (MWD) at Pacoima Spreading Grounds on a yearly basis.

(D) Tujunga Spreading Grounds will be taken out of service during the water years of 2011-13 for modifications to increase storage

(E) The values shown for Los Angeles on this extraction plan are estimates only. The estimated groundwtaer pumping amounts for wellfields may be increased as treatment faculities are installed or as the blending with external source of water will continue to be allowable.

amec foster wheeler

ATTACHMENT 6

FFS Figures 4-15 and 4-17

LEGEND

- PROPOSED NHOU EXTRACTION WELL – ALTERNATIVES 2A, 3A, 4A, AND 5A
- EXISTING NHOU EXTRACTION WELL – ALTERNATIVES 2A, 3A, 4A, AND 5A
- ACTIVE PRODUCTION WELL
- FACILITY MONITORING WELL
- REMEDIAL INVESTIGATION MONITORING WELL
- NHOU WELL COLLECTOR PIPELINE
- VOC TARGET VOLUME (µg/L)
- CHROMIUM TARGET VOLUME (µg/L)

FLOWLINES ORIGINATING AT TARGET VOLUME BOUNDARY IN DEPTH REGION 1

- FLOWLINES TRAVELING THROUGH DEPTH REGION 1
- FLOWLINES TRAVELING THROUGH DEPTH REGION 2
- FLOWLINES TRAVELING THROUGH DEPTH REGION 3

NOTE: FLOWLINES FOR REINJECTION OPTION ARE NOT SHOWN.

FIGURE 4-15
ALTERNATIVES 2A, 3A, 4A, AND 5A: EXPANSION OF NHOU EXTRACTION WELL FIELD, FLOWLINES ORIGINATING IN DEPTH REGION 1, FORECAST AVERAGE PRODUCTION SCENARIO
NORTH HOLLYWOOD OPERABLE UNIT
FOCUSED FEASIBILITY STUDY
SAN FERNANDO VALLEY AREA 1 SUPERFUND SITE

\\BALDUR\PROJ\NORTH_HOLLYWOOD\MXDS\FFS_JAN03_APR07\FIG04-15_ALT234_VOCAVG-DR1.MXD FELHADID 6/26/2009 15:47:02

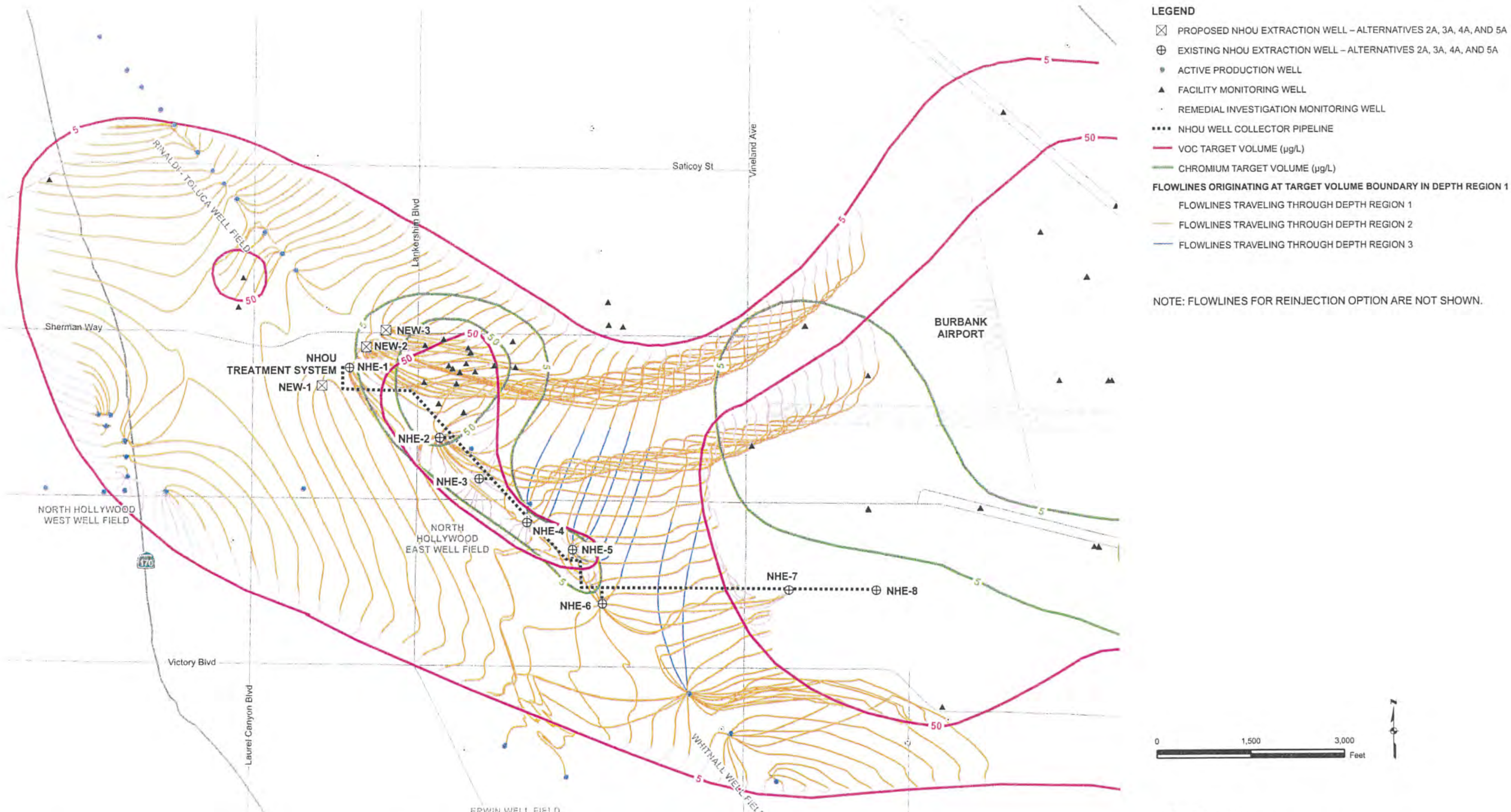


FIGURE 4-17
ALTERNATIVES 2A, 3A, 4A, AND 5A: EXPANSION OF NHOU EXTRACTION WELL FIELD, FLOWLINES ORIGINATING IN DEPTH REGION 1, FORECAST MAXIMUM PRODUCTION SCENARIO
NORTH HOLLYWOOD OPERABLE UNIT
FOCUSED FEASIBILITY STUDY
SAN FERNANDO VALLEY AREA 1 SUPERFUND SITE

\\BALDUR\PROJ\NORTH_HOLLYWOOD\MXDS\FFS_JAN03_APR07\FIG04-17_ALT234_VOCDRY-DR1.MXD FELHADID 6/11/2009 14:15:36

APPENDIX B

Simulation F Model Detailed Evaluation

APPENDIX B
SIMULATION F MODEL EVALUATION
North Hollywood Operable Unit
Second Interim Remedy
Groundwater Remediation Design

1.0 INTRODUCTION

On June 13, 2013, Amec Foster Wheeler held a conference call with USEPA and its consultant CH2M Hill to address questions regarding the results of NHOU forecast model Scenario F provided to Amec Foster Wheeler on May 29, 2013. On June 14, 2013, updated model file directories for Simulation F (ScenarioF_Verified.zip) were posted to the USEPA project website for review and include the following files:

1. A set of MODFLOW-SURFACT input files for run r712i,
2. A Groundwater Vistas (GWV) file for model run r712 (r712i_AddNHE-2_CorrectFlows.gwv),
3. A spreadsheet (Recharge_Check.xls) comparing specified and simulated non-spreading recharge, and
4. A spreadsheet (WellText_VerifyScenF.csv) with a well import file for GWV.

Amec Foster Wheeler staff ran the Simulation F model as provided by USEPA using MODFLOW-SURFACT, a proprietary version of MODFLOW. In addition, Simulation F model files were converted to run using MODFLOW-NWT, a more recent version of USGS MODFLOW in the public domain that has capabilities similar to MODFLOW-SURFACT.

Water Budget Spreadsheet

Previously, USEPA had provided a water balance spreadsheet that presents an annualized water budget for the San Fernando Valley based on the water year for the period 2012/13 through 2039/40. This budget is consistent with projections contained in the draft Groundwater Management Plan (GMP). Various assumptions were made regarding municipal pumping, remediation pumping, artificial recharge, and natural recharge as discussed below.

1. NHOU pumping is assumed to increase from 1937 acre-feet per year (AFY) to 4,923 AFY starting in 2015. NHOU production remains at 4,923 AFY for the remainder of the forecast period.
2. LADWP production increases significantly starting in 2019 with the addition of pumping from North Hollywood West at 30,890 AFY, North Hollywood East at 5,620 AFY, and Rinaldi-Toluca at 33,492 AFY. Tujunga production also increases in 2019 from 15,674 to 31,897 AFY.

3. Surface water spreading (recharge) appears to be based on the historic record, with wet and dry years. Recharge rates range between 9,400 and 112,240 AFY and includes assumed constant recharge of 6,200 AFY at Pacoima starting in 2012. Additional groundwater recharge is assumed to occur at Hansen and Pacoima starting in 2024 at 15,000 AFY, increasing to 22,500 AFY in 2029, and 30,000 AFY in 2034.
4. Surface water credits of about 2,000 AFY are assumed to start in 2019 at Hansen, Pacoima, and Tujunga, increasing to 4,000 AFY in 2024, 8,000 AFY in 2029, and 15,000 AFY in 2034.
5. Other recharge (Valley Fill, Return Flows, and Mountain Front Recharge) are variable annually, and appear to represent dry and wet periods. The basis for the recharge values is not presented in the accompanying report, but the Draft GMP indicates that recharge was varied in 11-year cycles based on data from 1998-99 through 2008-09.
6. Total predicted change in storage (recharge minus withdrawals) is estimated to be 108,000 AF at the end of the 28-year period.

Model Files

The supplied Groundwater Vistas model file r712i.gwv was used to prepare and run the model using MODFLOW-SURFACT version 3.0. The resulting model output heads and water balance summary were used to compare model inputs/output with the proposed water balance spreadsheet for each 1-year long stress period as discussed below.

Heads in the NHOU area for the r712i run range between 445 and 450 feet above mean sea level (AMSL) at the end of the simulation period (Figure B1). This is approximately equal to the heads reported in the October 27, 2012 memorandum (CH2M Hill, 2012).

The simulated head at a hypothetical observation well in layer 1 near NHE-2 (Figure B2) shows a rise and fall similar to that presented in Figure 2 of the October 27, 2012 memorandum (CH2M Hill, 2012).

Forward particle tracks in model layer 1 and 2 for the r712i run are attached (Figure B3). Differences between these and Figure 3 of the October 27, 2012 memorandum (CH2M Hill, 2012) are apparent. Many particles released in model migrate to the southeast and are not contained within the NHOU area.

Water Budget Spreadsheet vs Model Water Balance

The proposed water budget spreadsheet and the simulated water balance were compared to attempt to identify differences that may be causing the discrepancies between the model simulation and the October 27, 2012 memorandum (CH2M Hill, 2012). The differences are provided on the accompanying Table B1 which shows these differences corresponding to the entries in the proposed water budget spreadsheet.

1. Comparison of simulated water balance and the water budget spreadsheet shows significant differences between the proposed pumping and the simulated pumping (Table B1, Figure B4). At the end of the simulation period, cumulative proposed withdrawals were 3,217,815 AF while the simulated cumulative pumping was 3,164,142 AF, a discrepancy of 53,673 AF of additional pumping. Most of the lost pumping is from the NHOU extraction well field (-11,812 AF) and BOU extraction (-20,889 AF) near the end of the simulation. Additional losses occur at Mission (-19,060 AF) and Vulcan (-5840 AF) wells throughout the simulation.
2. Comparison of simulated water balance and the water budget spreadsheet shows slight differences between the proposed recharge by spreading and simulated recharge by spreading (Table B1, Figure B5). At the end of the simulation period, cumulative proposed spreading was 1,376,784 AF while the simulated spreading (well inflow) was 1,375,979 AF, a discrepancy of -805 AF of recharge.
3. Comparison of simulated water balance and the water budget spreadsheet shows slight differences between the proposed recharge by others (valley fill, return flows, and mountain front recharge) and simulated recharge by others (Table B1, Figure B6). At the end of the simulation period, cumulative proposed recharge by others was 1,949,048 AF while the simulated recharge by others (areal RCH) was 1,947,902 AF, a discrepancy of -1,950 AF of recharge.
4. Comparison of simulated water balance and the water budget spreadsheet shows a significant difference between the proposed net change in storage (recharge - withdrawals) and simulated net change in storage (Table B1, Figures B7 and B8). At the end of the simulation period, cumulative net change in storage was -108,016 AF (indicating a gain in storage) while the simulated net change in storage was 159,739 AF (indicating an increase in storage), a discrepancy of 51,723 AF. Most of this can be attributed to the 53,673 AF of lost pumping in the simulation.

2.0 CONCLUSIONS

1. The model file provided appear to encode the projections included in the Draft GMP and summarized in the October 27, 2012 memorandum.
2. However, the simulation results show that the LADWP projections are not sustainable during the later part of the simulation and the significant pumping losses may occur. Examples of this include lack of presence of NEW-3 in the simulation, complete loss of pumping from NEW-1 and NEW-2, and partial loss of pumping in NHE-3, -4, and -5. Loss of pumping also occurs at the Mission and Vulcan wells.

3. The simulation appears to represent pumping of the NH East well field as at NH-2 and NH-30 only, with rates of 1,740 gpm each, rather than as split among several wells at 500 gpm each as had been discussed previously in Simulation E (CH2M Hill, 2009). The concentration of flow at only two wells may have a more pronounced effect on contaminant migration than a more distributed yield.

4. The GWV file appears to incorporate many changes to well screen intervals from the FFS model in response to MWH discovery that many such screened intervals were inconsistent with the data in the USEPA well construction database. However, some discrepancies still exist, although they may not be too influential on the model predictions.

5. Particle tracking indicate that some particles released in model migrate to the southeast and are not contained within the NHOU area. Some of the particles may be captured by LADWP wells or even migrate into the Glenburn area.

6. Particle tracking also indicates that vertical migration of some particles in to deeper layers may occur through cross communication via wells, or descend into lower layers as the water table declines.

3.0 REFERENCES

CH2M Hill, 2009. Results for Preliminary Modeling of Potential Impacts of revised LADWP Proposed Pumping and Recharge Rates (“Simulation E”) on NHOU Effectiveness. June 23, 2009.

CH2M Hill, 2012. Potential Impacts of Los Angeles Department of Water & Power’s Proposed Pumping Plan on Selected Areas of North Hollywood and Glendale Operable Units. October 27, 2012.

TABLE

TABLE B1

SCENARIO F MODEL INPUTS/OUTPUTS SUMMARY
North Hollywood Operable Unit
Second Interim Remedy
Groundwater Remediation Design

Model Pumping Scenario	Well Field or Recharge Basin	Water Year (July 1 through June 30) 2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36	2036-37	2037-38	2038-39	2039-40	2014-2019 Avg Net Annual Withdrawal
"2012_F"	Scenario-F Wells Out Surfact	-57,654	-50,598	-46,109	-47,509	-47,585	-47,556	-47,524	-103,588	-127,085	-139,536	-139,478	-139,398	-144,370	-143,539	-143,279	-143,321	-143,226	-156,891	-156,749	-156,650	-155,972	-154,972	-171,973	-170,608	-169,384	-168,266	-167,836	-167,702	-3,508,358
	Delta Pumping	-2,674	-2,618	-5,131	-4,754	-4,830	-4,801	-4,769	-4,831	-13,105	-12,556	-12,498	-12,418	-13,390	-12,559	-12,299	-12,341	-12,246	-14,411	-14,269	-14,170	-13,492	-12,492	-14,993	-13,628	-12,404	-11,286	-10,856	-10,722	-290,543
	Total All Wells:	*54,980*	*47,980*	*40,978*	*42,755*	*42,755*	*42,755*	*42,755*	*98,757*	*113,980*	*126,980*	*126,980*	*126,980*	*130,980*	*130,980*	*130,980*	*130,980*	*130,980*	*142,480*	*142,480*	*142,480*	*142,480*	*142,480*	*156,980*	*156,980*	*156,980*	*156,980*	*156,980*	*156,980*	-58549
	Total LADWP Wells:	*35,000*	*28,000*	*20,998*	*22,775*	*22,775*	*22,775*	*22,775*	*78,777*	*94,000*	*107,000*	*107,000*	*107,000*	*111,000*	*111,000*	*111,000*	*111,000*	*111,000*	*122,500*	*122,500*	*122,500*	*122,500*	*122,500*	*137,000*	*137,000*	*137,000*	*137,000*	*137,000*	*137,000*	3,217,815
	NHOU Extraction:	1,937	1,937	1,937	4,923	4,923	4,923	4,923	4,923	4,923	4,923	4,923	4,923	4,923	4,923	4,923	4,923	4,923	4,923	4,923	4,923	4,923	4,923	4,923	4,923	4,923	4,923	4,923	4,923	
	North Hollywood West:	2,967	1,567	1,211	0	0	0	0	16,890	15,890	30,890	30,890	30,890	30,890	30,890	30,890	30,890	30,890	30,890	30,890	30,890	30,890	30,890	30,890	30,890	30,890	30,890	30,890	30,890	
	North Hollywood East:	0	0	0	0	0	0	0	5,620	5,620	5,620	5,620	5,620	5,620	5,620	5,620	5,620	5,620	5,620	5,620	5,620	5,620	5,620	5,620	5,620	5,620	5,620	5,620	5,620	
	Rinaldi-Toluca:	4,451	2,350	0	0	0	0	0	33,492	33,492	32,492	32,492	32,492	34,492	34,492	34,492	34,492	34,492	40,242	40,242	40,242	40,242	40,242	47,492	47,492	47,492	47,492	47,492	47,492	
	Tujunga:	15,674	15,674	15,674	15,674	15,674	15,674	15,674	15,674	31,897	30,897	30,897	30,897	32,897	32,897	32,897	32,897	32,897	38,647	38,647	38,647	38,647	38,647	45,897	45,897	45,897	45,897	45,897	45,897	
	Erwin:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Whitnall:	5,106	1,741	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Verdugo:	2,687	2,553	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Pollock:	2,178	2,178	2,176	2,178	2,178	2,178	2,178	2,178	2,178	2,178	2,178	2,178	2,178	2,178	2,178	2,178	2,178	2,178	2,178	2,178	2,178	2,178	2,178	2,178	2,178	2,178	2,178	2,178	
	BOU Extraction:	10,162	10,162	10,162	10,162	10,162	10,162	10,162	10,162	10,162	10,162	10,162	10,162	10,162	10,162	10,162	10,162	10,162	10,162	10,162	10,162	10,162	10,162	10,162	10,162	10,162	10,162	10,162	10,162	
	Total Other SFV Wells:	9,818	9,818	9,818	9,818	9,818	9,818	9,818	9,818	9,818	9,818	9,818	9,818	9,818	9,818	9,818	9,818	9,818	9,818	9,818	9,818	9,818	9,818	9,818	9,818	9,818	9,818	9,818	9,818	
	Scenario-F Wells In Surfact	9,403	24,125	20,294	20,850	67,203	29,305	27,423	77,263	28,165	18,254	24,516	11,402	43,114	39,283	39,839	86,192	48,294	57,905	105,746	56,648	46,738	52,999	54,376	69,099	65,268	65,824	112,176	74,279	1,375,979
	Delta Spreading	-5	-14	-12	-12	-39	-17	-16	-45	-16	-11	-14	-7	-25	-23	-23	-50	-28	-34	-62	-33	-27	-31	-32	-40	-38	-38	-66	-43	-805
	Total Spreading Basins:	*-9,408*	*-24,139*	*-20,306*	*-20,862*	*-67,242*	*-29,322*	*-27,439*	*-77,308*	*-28,181*	*-18,265*	*-24,530*	*-11,408*	*-43,139*	*-39,306*	*-39,862*	*-86,242*	*-48,322*	*-57,939*	*-105,808*	*-56,681*	*-46,765*	*-53,030*	*-54,408*	*-69,139*	*-65,306*	*-65,862*	*-112,242*	*-74,322*	*-1,376,784*
	Branford (historic):	-460	-562	-468	-547	-641	-415	-345	-585	-462	-444	-932	-460	-562	-468	-547	-641	-415	-345	-585	-462	-444	-932	-460	-562	-468	-547	-641	-415	
	Hansen (historic):	-1,342	-11,694	-7,487	-8,949	-28,129	-9,809	-8,232	-35,137	-12,052	-6,424	-9,427	-1,342	-11,694	-7,487	-8,949	-28,129	-9,809	-8,232	-35,137	-12,052	-6,424	-9,427	-1,342	-11,694	-7,487	-8,949	-28,129	-9,809	
	Lopez (historic):	-544	-172	-578	-536	-378	-724	-363	-1,086	-182	-144	-518	-544	-172	-578	-536	-378	-724	-363	-1,086	-182	-144	-518	-544	-172	-578	-536	-378	-724	
	Pacoima (historic):	-761	-3,826	-2,909	-696	-20,714	-5,768	-4,532	-14,064	-3,156	-1,731	-3,539	-761	-3,826	-2,909	-696	-20,714	-5,768	-4,532	-14,064	-3,156	-1,731	-3,539	-761	-3,826	-2,909	-696	-20,714	-5,768	
	Tujunga (historic):	-101	-1,685	-2,664	-3,934	-11,180	-6,406	-7,767	-18,236	-4,129	-1,322	-1,914	-101	-1,685	-2,664	-3,934	-11,180	-6,406	-7,767	-18,236	-4,129	-1,322	-1,914	-101	-1,685	-2,664	-3,934	-11,180	-6,406	
	Projected Burbank Recharge at Pacoima:	-6,200	-6,200	-6,200	-6,200	-6,200	-6,200	-6,200	-6,200	-6,200	-6,200	-6,200	-6,200	-6,200	-6,200	-6,200	-6,200	-6,200	-6,200	-6,200	-6,200	-6,200	-6,200	-6,200	-6,200	-6,200	-6,200	-6,200	-6,200	
	Surface Water Credit (SWC)	0	0	0	0	0	0	0	-2,000	-2,000	-2,000	-2,000	-2,000	-4,000	-4,000	-4,000	-4,000	-4,000	-8,000	-8,000	-8,000	-8,000	-8,000	-15,000	-15,000	-15,000	-15,000	-15,000	-15,000	
	Groundwater Recycling (GWR)	0	0	0	0	0	0	0	0	0	0	0	0	-15,000	-15,000	-15,000	-15,000	-15,000	-22,500	-22,500	-22,500	-22,500	-22,500	-30,000	-30,000	-30,000	-30,000	-30,000	-30,000	
	Hansen (new-SWC):	0	0	0	0	0	0	0	-740	-740	-740	-740	-740	-1,480	-1,480	-1,480	-1,480	-1,480	-2,960	-2,960	-2,960	-2,960	-2,960	-5,550	-5,550	-5,550	-5,550	-5,550	-5,550	
	Pacoima (new-SWC):	0	0	0	0	0	0	0	-360	-360	-360	-360	-360	-720	-720	-720	-720	-720	-1,440	-1,440	-1,440	-1,440	-1,440	-2,700	-2,700	-2,700	-2,700	-2,700	-2,700	
	Tujunga (new-SWC):	0	0	0	0	0	0	0	-900	-900	-900	-900	-900	-1,800	-1,800	-1,800	-1,800	-1,800	-3,600	-3,600	-3,600	-3,600	-3,600	-6,750	-6,750	-6,750	-6,750	-6,750	-6,750	
	Hansen (new-GWR):	0	0	0	0	0	0	0	0	0	0	0	0	-7,500	-7,500	-7,500	-7,500	-7,500	-11,250	-11,250	-11,250	-11,250	-11,250	-15,000	-15,000	-15,000	-15,000	-15,000	-15,000	
	Pacoima (new-GWR):	0	0	0	0	0	0	0	0	0	0	0	0	-7,500	-7,500	-7,500	-7,500	-7,500	-11,250	-11,250	-11,250	-11,250	-11,250	-15,000	-15,000	-15,000	-15,000	-15,000	-15,000	
	Scenario-F Surfact	60,136	75,836	66,380	58,118	87,345	67,251	60,291	93,069	62,212	62,274	73,534	60,136	75,836	66,380	58,118	87,345	67,251	60,291	93,069	62,212	62,274	73,534	60,136	75,836	66,380	58,118	87,345	67,251	1,947,956
	Delta RCH	-35	-19	-27	-34	-36	-53	-35	-62	-43	-67	-32	-35	-19	-27	-34	-36	-53	-35	-62	-43	-67	-32	-35	-19	-27	-34	-36	-53	-1,092
	Total Other Recharge:	*-60,171*	*-75,855*	*-66,407*	*-58,152*	*-87,381*	*-67,304*	*-60,326*	*-93,131*	*-62,255*	*-62,341*	*-73,566*	*-60,171*	*-75,855*	*-66,407*	*-58,152*	*-87,381*	*-67,304*	*-60,326*	*-93,131*	*-62,255*	*-62,341*	*-73,566*	*-60,171*	*-75,855*	*-66,407*	*-58,152*	*-87,381*	*-67,304*	*-1,949,048*
	Recharge in Valley Fill:	-4,133	-13,561	-10,309	-6,815	-25,732	-10,539	-8,357	-22,717	-7,079	-6,600	-13,484	-4,133	-13,561	-10,309	-6,815	-25,732	-10,539	-8,357	-22,717	-7,079	-6,600	-13,484	-4,133	-13,561	-10,309	-6,815	-25,732	-10,539	
	Delivered Water Return:	-54,825	-58,007	-52,904	-49,368	-55,072	-53,750	-49,233	-64,709	-52,974	-53,521	-56,256	-54,825	-58,007	-52,904	-49,368	-55,072	-53,750	-49,233	-64,709	-52,974	-53,521	-56,256	-54,825	-58,007	-52,904	-49,368	-55,072	-53,750	
	Mountain Front Recharge:	-1,213	-4,287	-3,194	-1,969	-6,577	-3,015	-2,736	-5,705	-2,202	-2,220	-3,826	-1,213	-4,287	-3,194	-1,969	-6,577	-3,015	-2,736	-5,705	-2,202	-2,220	-3,826	-1,213	-4,287	-3,194	-1,969	-6,577	-3,015	
	Scenario-F Total RCH Surfact	69,539	99,961	86,674	78,967	154,548	96,556	87,714	170,332	90,376	80,528	98,050	71,537	118,950	105,663	97,956	173,537	115,545	118,196	198,815	118,860	109,012	126,533	114,512	144,935	131,648	123,941	199,522	141,529	3,323,935
	Delta Total RCH	-41	-33	-39	-47	-75	-70	-51	-107	-60	-78	-46	-42	-44	-50	-58	-86	-81	-69	-124	-76	-94	-63	-67	-59	-65	-73	-101	-97	-1,897
	Total Recharge:	*-69,579*	*-99,994*	*-86,713*	*-79,014*	*-154,623*	*-96,626*	*-87,765*	*-170,439*	*-90,436*	*-80,606*	*-98,096*	*-71,579*	*-118,994*	*-105,713*	*-98,014*	*-173,623*	*-115,626*	*-118,265*	*-198,939*	*-118,936*	*-109,106*	*-126,596*	*-114,579*	*-144,994*	*-131,713*	*-124,014*	*-199,623*	*-141,626*	*-3,325,832*
	Net Withdrawal (negative if recharge exceeds pumping):	-14,599	-52,014	-45,735	-36,259	-111,868	-53,871	-45,010	-71,682	23,544	46,374	28,884	55,401	11,986	25,267	32,966	-42,643	15,354	24,215	-56,459	23,544	33,374	15,884	42,401	11,986	25,267	32,966	-42,643	15,354	-108,016
	Scenario-F Net Withdrawal Surfact (negitive if RCH exceeds Pumping)	-11,884	-49,363	-40,565	-31,458	-106,963	-49,000	-40,189	-66,744	36,709	59,008	41,428	67,861	25,420	37,876	45,323	-30,215	27,681	38,695	-42,065	37,791	46,961	28,439	57,461	25,673	37,737	44,325	-31,686	26,172	184,423
	Phase of New Pumping/Recharge Implementation:					New NHOU Extraction Well Pumping Rates			Implement Centeralized LADWP VOC Treatment, New LADWP Recharge from Advanced Water Treatment Process and improve storm water capture projects, Continue New NHOU Pumping and Increased LADWP Pumping Rates																					
Cumulate Net Change in storage		14,599	66,613	112,348	148,607	260,475	314,346	359,356	431,038	407,494	361,120	332,236	276,835	264,849	239,582	206,616	249,259	233,905	209,690	266,149	242,605	209,231	193,347	150,946	138,960	113,693	80,727	123,370	108,016	
		11,884	61,248	101,813	133,271	240,234	289,234	329,423	396,167	359,459	300,450	259,023	191,162	165,742	127,866	82,544	112,759	85,078	46,383	88,449	50,658	3,698	-24,741	-82,202	-107,875	-145,612	-189,937	-158,251	-184,423	
		11,884																												

Notes:
LADWP Anticipated Maximum Pumping Scenario from San Fernando Basin Based on the Urban Management water Plan (UMWP) of 2010.
Cells highlited with pink color are added or revised by LADWP.
Burbank projected in the Groundwater Pumping and Spreading Plan (July 2011) to spread 6,200 AF of imported water at Pacoima Spreading Grounds.

FIGURES

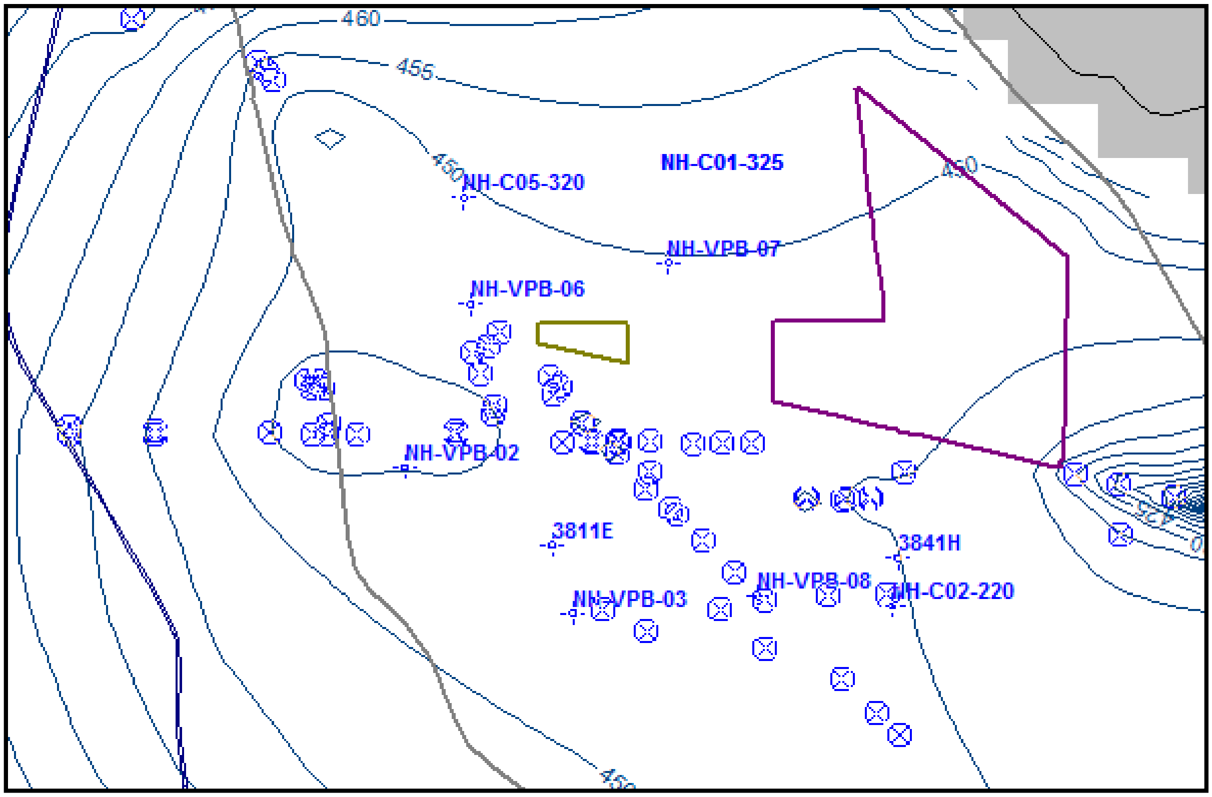


Figure B1 - Simulated heads in Model Layer 1 at the end of the simulation period (2039/40). The r712i heads are approximately equal to those presented in Figure 1 of the October 27, 2012 memo.

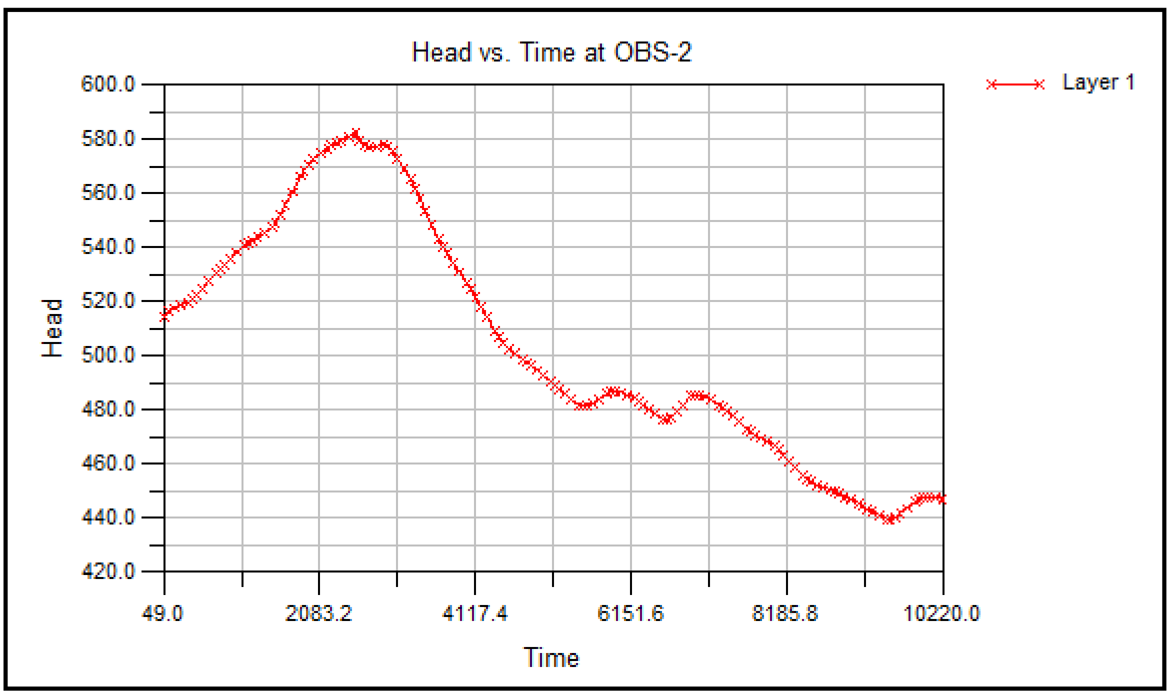


Figure B2 – Simulated hydrograph of hypothetical observation well adjacent to NHE-2. The simulated heads are approximately equal to those presented on Figure 2 of the October 27, 2012 memo.

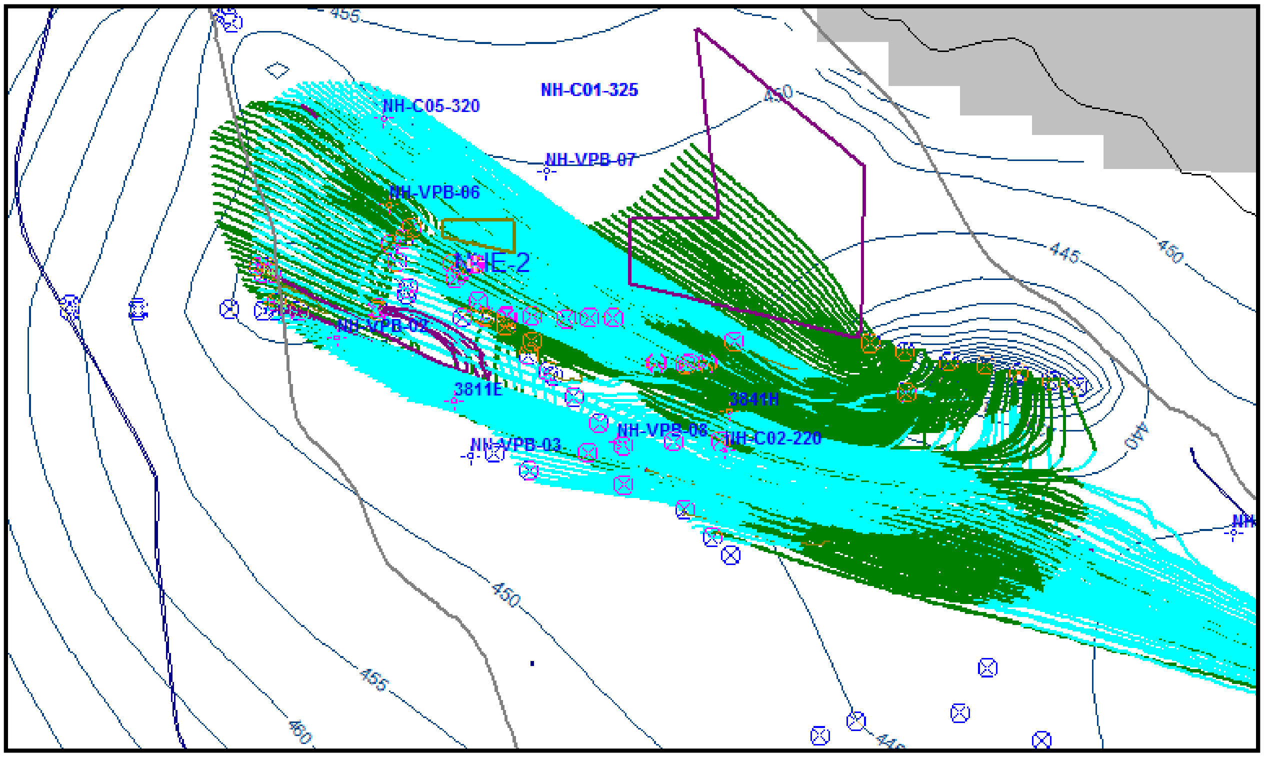


Figure B3 – Simulate forward particle tracks in model Layer 1 shows that many particles are migrating out of the NHOU containment area to the southeast. Some particles also appear to move down vertically into model layer 3 and 4. Note the dissimilarity with Figure 3 of the October 27, 2012 memo.

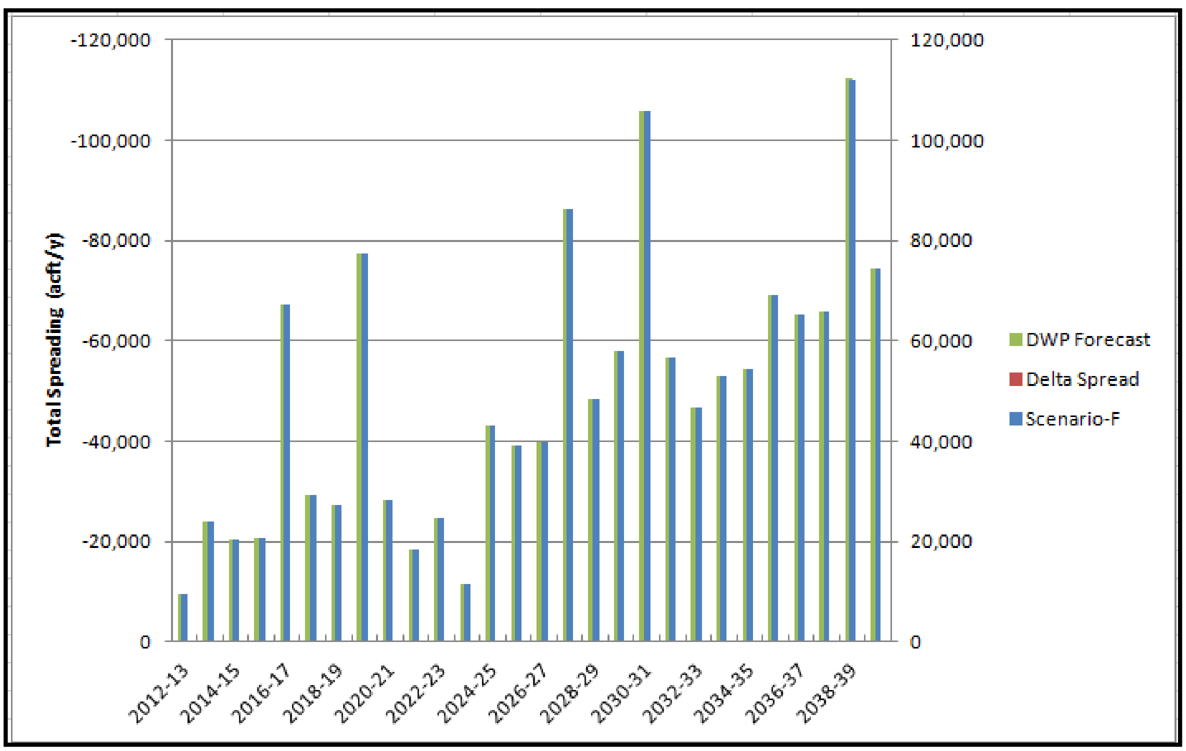


Figure B4 – Comparison of forecast and simulated annual production 2012/13 to 2039/40

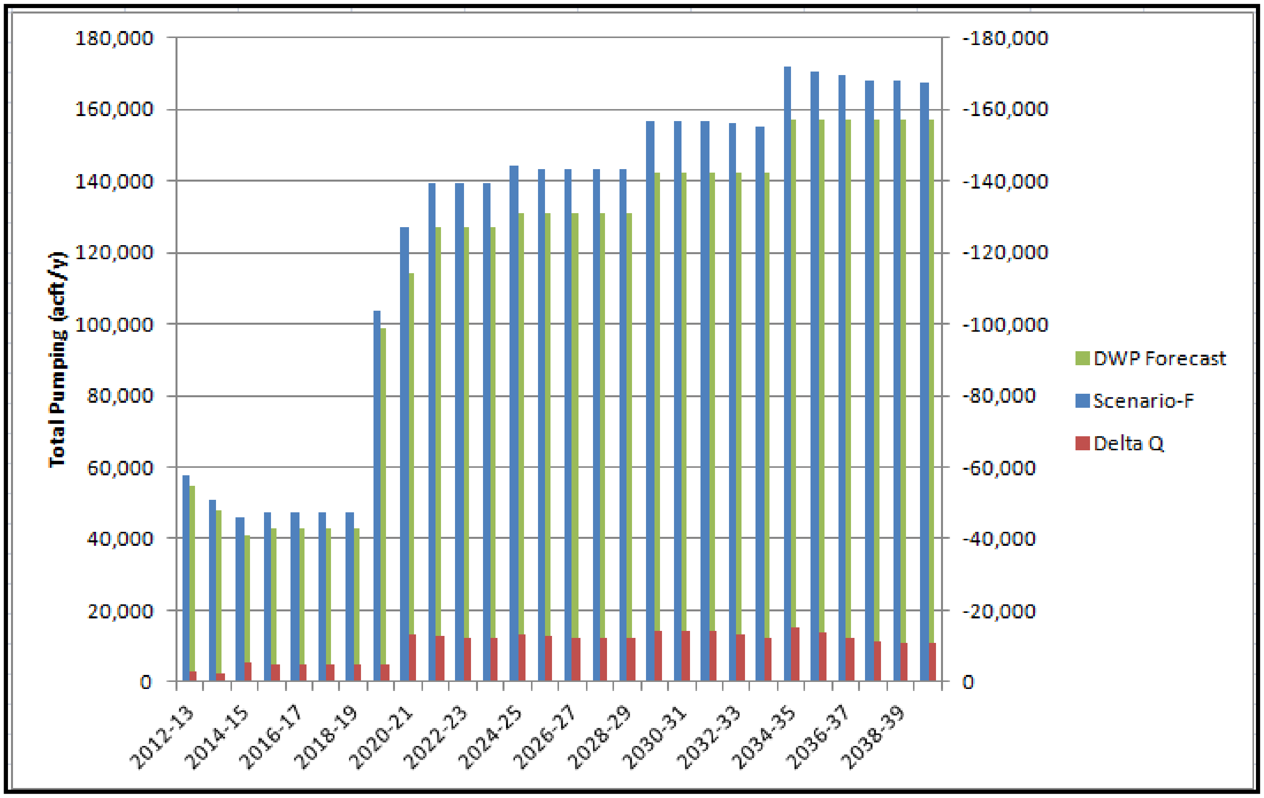


Figure B5 – Comparison of forecast and simulated annual spreading 2012/13 to 2039/40

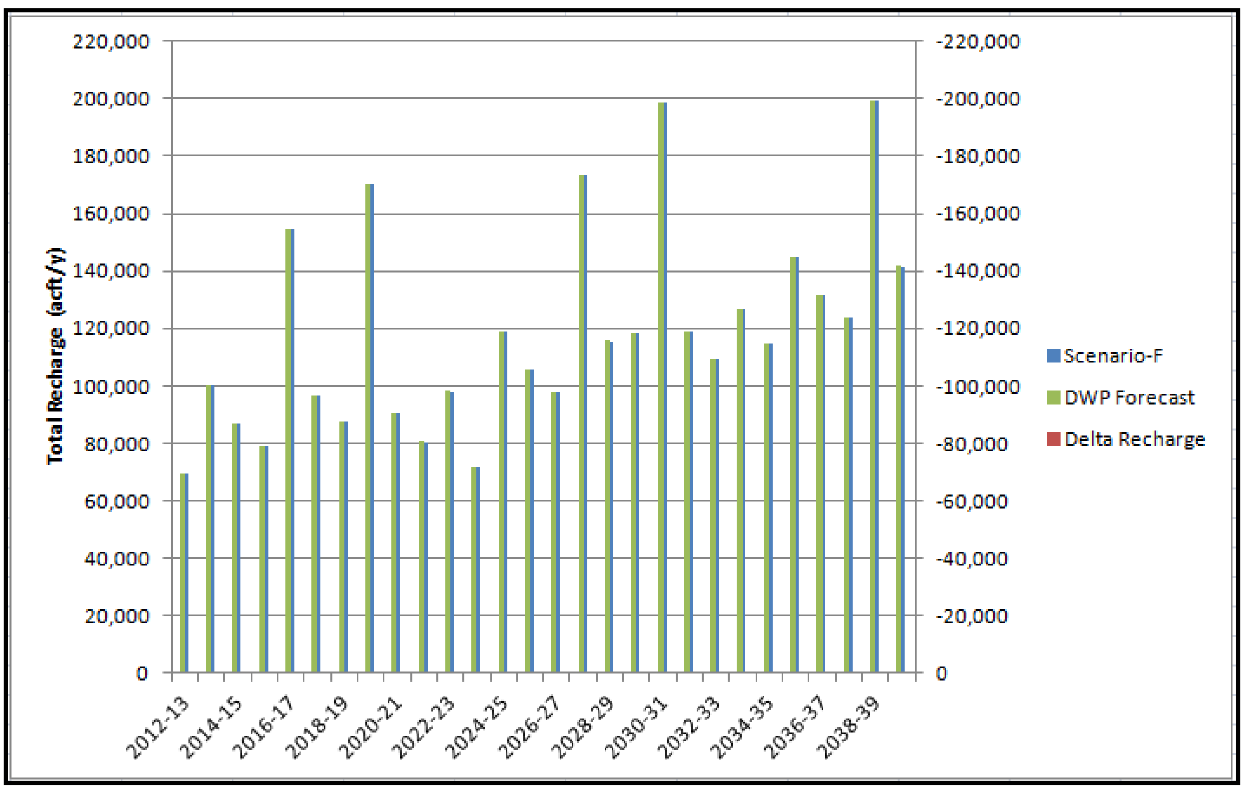


Figure B6 – Comparison of forecast and simulated annual recharge 2012/13 to 2039/40

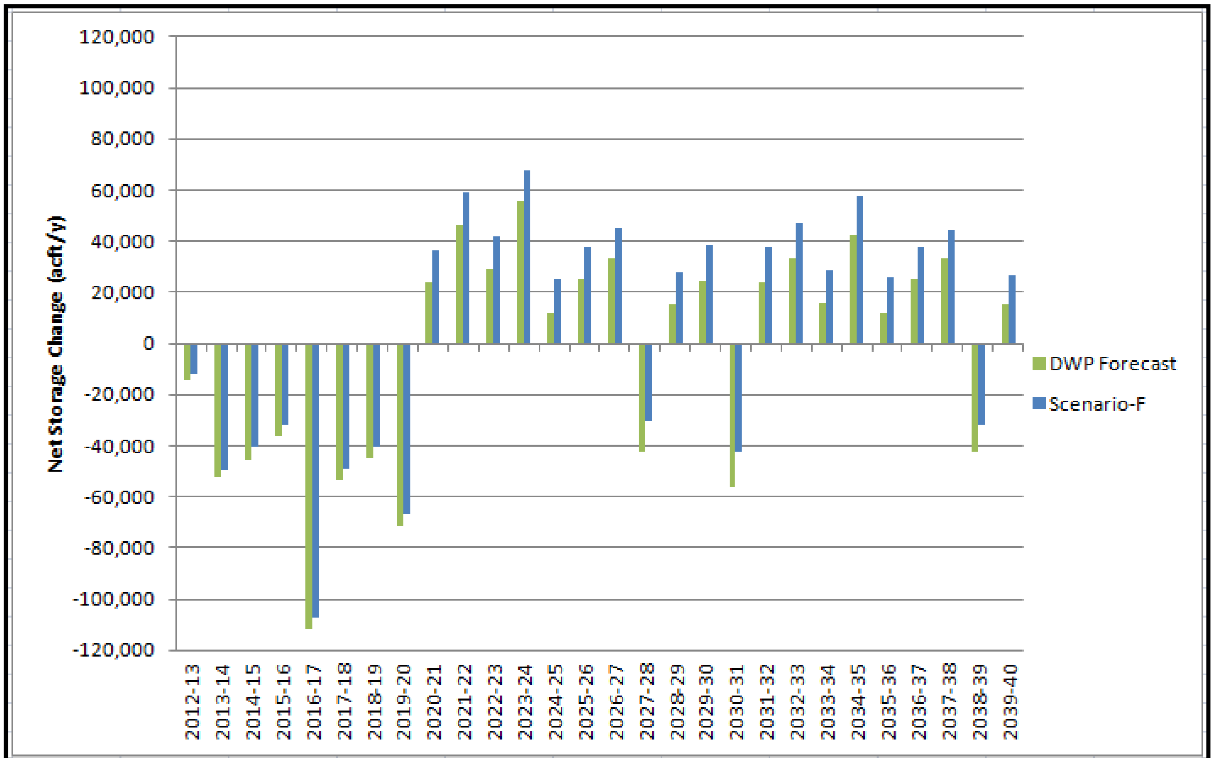


Figure B7 – Comparison of forecast and simulated annual net change in storage 2012/13 to 2039/40

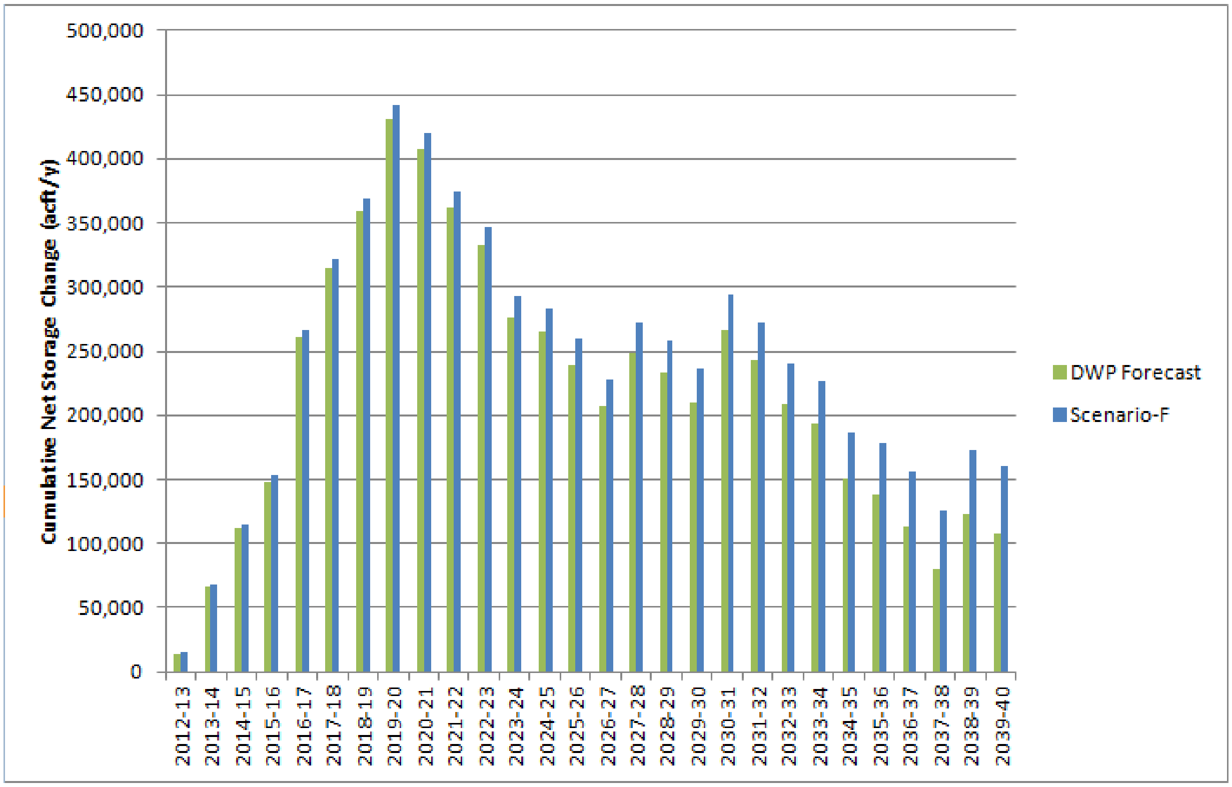


Figure B8 – Comparison of forecast and simulated cumulative change in storage 2012/13 to 2039/40

APPENDIX C

USEPA 2013 Model Update Detailed Evaluation

APPENDIX C
USEPA 2013 MODEL UPDATE EVALUATION
North Hollywood Operable Unit
Second Interim Remedy
Groundwater Remediation Design

1.0 INTRODUCTION

In 2013, CH2M Hill issued a report (USEPA, 2013) documenting changes made to the SFB model to include more recent data from the date of the previous update including added monitoring well water level data, a 2010 pumping test at the BOU, and stresses from spreading ground and water supply and remedial extraction well rates. The model revision also included reintroduction of the Verdugo Fault as a feature potentially influencing groundwater flow in the SFV. This appendix includes a summary and review performed by Amec Foster Wheeler, including some comparisons to the previous model that had been calibrated for the FFS.

COMMENTS AND OBSERVATIONS ON THE MODEL

The following summarizes the changes made in the 2013 EPA model:

- Increased grid spacing which decreased the number of rows and columns to 85 rows and 112 columns. Additional rows and columns were added to areas north of North Hollywood and Burbank Operable Units (NHOU and BOU) in the vicinity of the Tujunga Investigation Area and the Verdugo Fault. The 2013 USEPA model update consists of 4 model layers as did the previous model.
- Converted the model from MODFLOW-SURFACT to the publicly available MODFLOW- NWT version of MODFLOW which has similar wet/dry handling capabilities.
- Extended the calibration period of the model from October 1981 through September 2011. Incorporated pumping rates, water levels, and spreading grounds inflows for the time period 2008 through 2011. For comparison, the USEPA 2007 model has a calibration period from October 1981 through September 2007.
- Increased the number of calibration targets to 118 wells. The additional wells are located to the north/northwest of the NHOU and BOU in the Tujunga Investigation Area and in the vicinity of the Verdugo Fault and are shown in Figure C-1.
- Spreading grounds inflow is represented as areal recharge. Previously, the spreading grounds inflow was represented in the model as injection wells.
- Evaluated results from BOU 2010 pump test and included as part of model calibration.
- Applied semi-automatic calibration using parameter estimation software PEST to assist in the calibration of the model.

Other comments include:

- The grid (85 rows by 112 columns) has been set back (from FFS of 243 rows by 272 columns) to only slightly more finely discretized than the original JMM and Watermaster versions (64 rows by 88 columns) and GOU (73 rows by 89 columns) models. No clear explanation is presented, but it may be to allow PEST to operate in a reasonable time. The report comments that this grid spacing may not be suitable for all needs, but that the grid may need to be further discretized for design support purposes or other uses.
- The conversion of the model to MODFLOW-NWT appears to produce closely matching water balance and computed heads to the MODFLOW-SURFACT based model.
- CH2M Hill trimmed a portion of the active model area in the southeast portion as they noted that there were rock outcrops that had been included in the active portion of layer 1.
- Although the addition of the Verdugo Fault had some effect, it is stated that the effect is likely not significant in further simulations.
- CH2M Hill evaluated two alternative models to the basic model. One included the Verdugo Fault with gaps across it in model layer 1 (higher conductance in the HFB) and also a north-south preferential horizontal anisotropy considering possible influences of the Pacoima and Tujunga Washes. Although the former alternative slightly improved the residuals, the latter did not. CH2M Hill left the fault with gaps for the final model.
- CH2M Hill notes that the water level data availability is much denser in some of the NHOU and BOU locations where transducers had been installed. These data were filtered where some of these locations had at least daily readings to yield an average monthly value. For the target data set there were a total of 9,464 values at about 120 locations.
- Data for the 2010 BOU pumping test were used. The assignment of weights seemed to be based more on (the inverse of) number of observations in specific areas. BOU data were weighted as 12.6 whereas those more numerous areas such as the NHOU and Glendale North had weights of 0.46 and 0.39 respectively. Other weighting schemes may be adopted. Block averaging effects may be more significant due to the larger block size on the residuals compared to the FFS and "Simulation F" models.
- In the discussion of PEST, they note that the parameters varied included Kh, Kh/Kz, Sy, and Verdugo Fault conductance. PEST estimates trended toward some very high or very low K values in some areas. The approach taken was to link adjacent K zones (horizontal and vertical) in order to buffer the effects over larger areas.
- In evaluating the two alternatives for the Verdugo Fault representation, it was acknowledged that there could be other or common factors that might have worked better. Final approach was to not change the anisotropy in the area of the washes.

- Section 6.1 concludes: "However, the model described here is well-calibrated to the calibration data using reasonable parameters and should be a suitable starting point for additional refinements that may be required for remedial design, fate and transport (flowline) predictions, or other applications to which it may be appropriately adapted."
- Changes in Ks and Sy in particular are discussed in Section 6.2 of the 2013 report, but with only a few specified resultant parameter values. Values, but only in ranges, are presented on accompanying figures.
- Section 6.4 in the 2013 report includes a sensitivity analysis with a table of ordered relative sensitivity parameter values. Essentially there are only a few significantly sensitive parameters (e.g., the seventh listed parameter has a relative sensitivity of only about 10% of the most sensitive parameter).

In the recommendations, CH2M Hill recommended that aquifer tests should be performed to gather data to support the remediation design.

The process of PEST estimation of parameter values in the NHOU area, constrained by linking the model layer 1 and layer 2 hydraulic conductivity (K) values produced a common value of about 290 feet per day. Successive calibrations of the model in the NHOU area resulted in the K increase from 100 to 150 and to 290 feet per day, solely on the basis of the calibration process. This latter value is much higher than supported by existing data for the shallow water table and may be an artifact of the PEST calibration process. Unconstrained, the value in the shallow aquifer would have been even higher. This value is critical in the design process as it will dictate the location, capture zone width, and required pumping rates to maintain containment and capture.

2.0 CALIBRATION RESULTS:

The 2013 EPA model had the following reported calibration statistics for the 2013 model update:

Residual mean: -1.58 ft

Residual sum of squares (RSS): 524,000

Residual standard deviation (RSTD): 8.87ft

Number of observation: 9,464

A direct comparison of calibration statistics with previous versions of the model is not possible because the EPA 2013 model update covers a longer calibration period (1981 to 2011) and has a different number of observations. Although more wells are used as calibration targets in the USEPA 2013 model update, water levels used as calibration targets are average values for each month. The USEPA 2013 model update is better calibrated compared to the USEPA 2007 (FFS) model.

A review of the time-series plots of observed and model-calculated head is difficult because 16 charts are displayed per page of the accompanying documentation report, making the charts small and difficult to review.

In the calibration comparison, the resultant revised model yields much better sum of the square of the residuals (about 480,492) than the FFS updated calibrated model (about 984,000), but this is probably mainly due to the lower weights assigned to the two areas with the greatest number of observations.

The average, RMS, and average absolute residuals are similar to the FFS calibrated model, whereas the RMS divided by the range is much lower (about one-third). This is likely due to the addition of observation locations to the north and northwest which inflates the range and hence lowers the quotient.

3.0 WATER BALANCE COMPARISON

Amec Foster Wheeler extracted results from the 2IR groundwater flow model through 116 stress periods and compared the water balances for it and the 2013 model update through its first 116 stress periods (29 years). Recharge in the 2013 model includes the spreading grounds, while in the FFS model recharge is a combination of aerial recharge through the MODFLOW recharge package plus input as injection wells with the SURFACT fractured well package. Comparison of the water balances for the two models at stress period 116 shows close approximation of the total recharge, and extraction by production and remediation wells for the cumulative volumes and time step rates. The differences between the two models seem to be most apparent in the river gain/loss and in the storage changes for the cumulative volume and for the river gain/loss for the time step. The storage rates at the time step seem to be converging toward each other.

There is no discussion in the 2013 report about the Los Angeles River boundary condition. It does not appear that this was adjusted as part of the model calibration process. It is not possible to determine what stage values or river conductance values were used for this boundary condition in the EPA 2013 model update and what changes, if any, were made to the boundary condition compared to earlier versions of the EPA model.

4.0 CONCLUSIONS

- Specified stage values or river conductance values used for the Los Angeles River boundary condition in the EPA 2013 model and present changes, if any, that were made to the boundary condition compared to earlier versions of the EPA model.
- Perform aquifer testing to provide important information about the hydraulic properties in the NHOU and help resolve the inconsistencies in hydraulic conductivity values used in the various versions of the EPA model.
- The grid spacing in the EPA 2013 model is too coarse to reasonably evaluate hydraulic capture and plume migration. Consider refining to a finer grid.

- In the conclusions, CH2M Hill acknowledges that actual data were limited, particularly along the Verdugo Fault that may be significant when evaluating conditions farther north/northwest of the NHOU, and that this model would be used as the official calibrated model as of this date as being better than the previous SFV model.

FIGURE

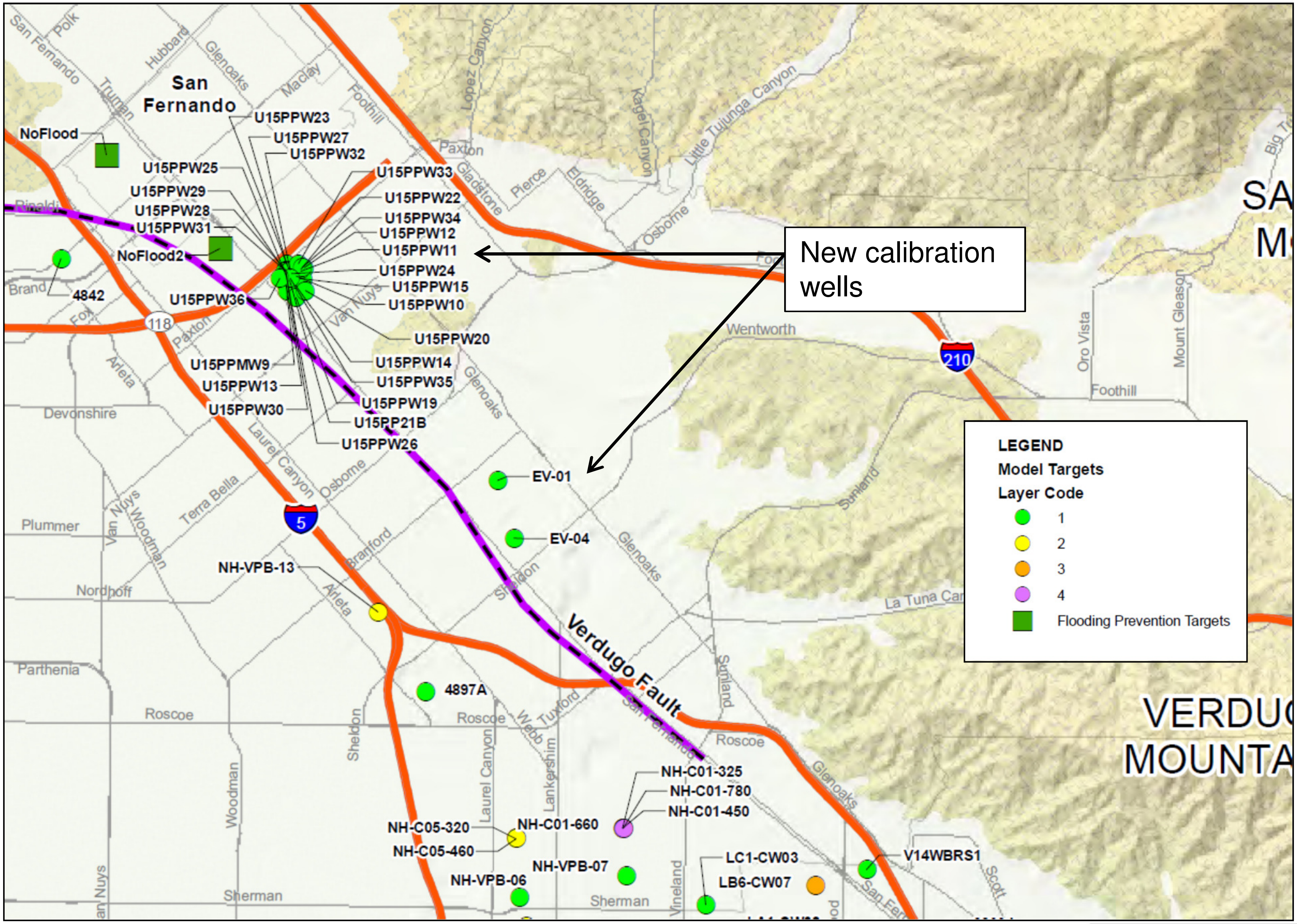


Figure C-1 - Location of new calibration wells in EPA 2013 model.

TETRA TECH, INC.

APPENDIX D

Amec Foster Wheeler Aquifer Test Analyses, Slug Pumping Tests Conducted during the Phase 1 Pre-Design Investigation

APPENDIX D
AQUIFER TEST ANALYSIS AND VERIFICATION
PHASE I PRE-DESIGN INVESTIGATION
North Hollywood Operable Unit
Second Interim Remedy
Groundwater Remediation Design

This Appendix presents a description and results of aquifer testing performed under the Phase 1 Pre-Design Investigation. These tests consisted of pneumatic slug tests at 14 locations, as reported in the Phase 1 Pre-Design Investigation – Groundwater Sampling, Vertical Flow Measurements, and Slug Test Findings report (AMEC, 2013), and constant rate discharge (CRD) tests at three NHE well locations, as described in the Phase 1 Pre-Design Investigation Report of Activities from July 2014 to February 2015 (Amec Foster Wheeler, 2015a). Additionally, “box” numerical groundwater flow models were constructed to augment and verify results of the CRD test analyses.

1.0 PNEUMATIC SLUG TESTS

Pneumatic slug tests were performed at 14 monitoring wells between January 3 and February 6, 2013. Tests were performed in accordance with the methods described in the SAP. The static water column at the test wells was displaced by the introduction of compressed nitrogen at multiple pressures to induce water column displacements of up to 2.5 feet. Time-drawdown curves were analyzed to estimate hydraulic conductivity (K) in each well using the AQTESOLV software package (Duffield, 2007). Calculated K values at each well relative to midpoint screen depth and individual curve matches are included in Attachment B of the Phase 1 Predesign investigation report (Amec, 2013).

For time-drawdown curve analysis, unconfined conditions were assumed for each test. The Springer-Gelhar (1991) analysis for curve fitting was employed for all time-drawdown curves. For non-oscillatory tests (i.e., critically damped), the Bouwer-Rice (1989) analysis was also performed, which yielded similar results to the Springer-Gelhar curve fits. For all analyses, it was assumed that there was no vertical anisotropy in the vicinity of the test well. Although this assumption may not necessarily be valid in all cases, and adjusting vertical anisotropy to match the groundwater flow model may yield greater K value estimates, the A-Zone and B-Zone pneumatic slug test data are consistent with the site conceptual model of a hydraulically distinct A-Zone overlying a relatively more permeable B-Zone. No significant correlation between pressure and hydraulic conductivity was observed in the data. Qualitatively, time-drawdown curves for wells screened within the A-Zone tended to show critically damped, or non-oscillatory, conditions.

A conservative estimate of the aquifer thickness was assumed in each case. For the A-Zone wells, the assumed saturated thickness was the water table elevation minus the estimated elevation of the A-Zone. For wells tested in the B-Zone or with screens across the A- and B-Zones, the saturated thickness was taken as the water table elevation minus the elevation of the bottom of the screen.

Pneumatic slug test results are summarized in Table 6 of the Phase 1 Predesign Report (AMEC, 2013). Tests at seven wells indicate an average A-Zone K value of 39.1 feet per day (ft/d) and a geometric mean of 38.7 ft/d, and tests at four wells indicate an average B-Zone K value of 86.2 ft/d and a geometric mean of 85.3 ft/d. Three wells tested were constructed with the well screen spanning both the A-Zone and B-Zone, and test results indicate an average K value of 74.6 ft/d and a geometric mean of 73.4 ft/d. Generally, K results for wells screened within the A-Zone ranged between 20 and 50 feet/day and for wells screened in either the B-Zone or between the A- and the B-Zone between 60 and 120 feet/day.

2.0 CRD TESTS

CRD testing was conducted at NHE-2, NHE-4, and NHE-7 in general accordance with ASTM D4050-14 (ASTM, 2014) to determine aquifer properties of the A-Zone. The original work plan specified testing of wells NHE-3, NHE-5, and NHE-7 and had to be revised because of increases in hexavalent chromium concentrations at NHE-3 and yield limitations at NHE-5. Water levels in the extraction well, associated shallow and deep piezometers, and in background monitoring wells were monitored and recorded by pressure transducers. An absolute pressure transducer was also used to monitor barometric pressure. A recovery test was performed upon completion of each CRD test.

2.1 NHE-2 CRD TEST

NHE-2 was pumped from 3:24 p.m. on November 20, 2014, to 3:30 p.m. on November 23, 2014, for a total of 72 hours of pumping. The pumping rate ranged from 119 gpm to 122 gpm over most of the test pumping period. The average pumping rate was 119.5 gpm, based on the starting and ending totalizer readings. During the pumping period, the drawdown in NHE-2 reached about 3.8 feet. Drawdown in the shallow and deeper piezometers reached approximately 1.1 and 0.35 feet, respectively.

2.2 NHE-7 PUMPING TEST

NHE-7 was pumped from 2:09 p.m. on December 10, 2014, to 2:11 p.m. on December 15, 2014, for a total of 120 hours of pumping. The pumping rate decreased from 334 gpm at the start of the CRD test to 256 gpm at the end of pumping. The variable pumping rate during the test may be attributed to falling head in the pumped well. The flow valve was not accessible at the wellhead; thus the flow rate was not corrected during the test. During the pumping period, the drawdown in NHE-7 reached about 35 feet, suggesting a well of relatively low efficiency. Drawdown in the shallow and deeper piezometers reached approximately 1.2 and 0.43 feet, respectively.

2.3 NHE-4 PUMPING TEST

NHE-4 was pumped from 12:04 p.m. on February 9, 2014, to 12:06 p.m. on November 23, 2014, for a total of 72 hours of pumping. The pumping rate decreased from 140 gpm at the start of the CRD test to 116 gpm at the end of pumping. The variable pumping rate during the test may be attributed to falling head in the pumped well. The flow valve was not accessible at the wellhead; thus the flow rate was not corrected during the test. During the pumping period, the drawdown in NHE-2 reached about 3.8 feet. Drawdown in the shallow and deeper piezometers reached approximately 1.1 and 0.35 feet, respectively.

2.4 ANALYSIS OF PUMPING TEST DATA

The analytical methods used to obtain values for aquifer hydraulic parameters were selected based on site hydrogeology and geometric relationship between the pumping and observation wells. The following analytical methods were used:

- Leaky unconfined aquifer solution with partially penetrating well (Moench, 1997; Neuman, 1974).
- Unconfined aquifer with variable rate and partial penetration (Theis, 1935).
- Leaky aquifer early-time solution with partially penetrating well (Hantush, 1960).

The software program AQTESOLV (an acronym of AQuifer TEst SOLVer; Duffield, 2007) was used to expedite fitting of type-curves to the hydraulic testing data. The corrected water level data expressed as drawdown in the spreadsheet files were imported to AQTESOLV. Curve-match results are illustrated on Figures 11a through 13d in the Phase 1 Pre-Design Investigation Report of Activities from July 2014 to February 2015 (Amec Foster Wheeler, 2015a). These analyses provided a best estimate of the aquifer K values at each pumping test location of 100 ft/d at NHE-2, 135 ft/d, at NHE-4, and 203 ft/d at NHE-7.

3.0 BOX MODEL SIMULATIONS OF THE PUMPING TESTS

The complex nature of the aquifer system compounded by the changing stresses in the aquifer led to situations in which the analysis of the pumping test data at the three pumped well locations (NHE-2, NHE-4, and NHE-7) had otentials to yield widely different estimates of hydraulic conductivity at each of the locations depending on the method used for analysis and the portion of the drawdown data one chose to more closely fit. In order to provide another line of analysis to verify that the estimates determined from the tests were reasonable. To accomplish this, three “box” numerical groundwater flow models were constructed using MODFLOW, one for each test location, to simulate each pumping test while optimizing the horizontal and vertical hydraulic parameters for the A-Zone to provide the best overall statistical fit to the data. Each model is intended to augment pumping test analyses to assure that the test analyses had resulted in representative values. Each model was constructed using the Groundwater Vistas modeling platform (ESI, 2010).

3.1 MODEL STRUCTURE

Each box model's domain is approximately 1,000 feet by 1,000 feet, and vertically consists of the interpreted A- and B-Zone thicknesses at each location. The grid spacing is variable, but with one-foot spacings for 50 feet in both row and column directions from the pumped well location situated at the center of the model (row 100, column 100). In total, each model consists of 199 rows and 199 columns. Figure D-1 presents a plan view of the model grid.

Vertically, each model includes nine layers to allow for individual layers to contain the test observation well screened intervals. The thicknesses of the A- and B-Zones were taken from the Data Gap Analysis report (Amec, 2012). Model layer 1 (numbered from the top down), represents the surface to the top of the shallow observation well/piezometer. Layer 2 corresponds to the elevation of the top and bottom of the shallow observation well screen. Layer 3 extends from the bottom of the shallow observation well screen to the bottom of the extraction well screen. Layer 4 extends from the bottom of the extraction well screen to the top of the deeper observation well screen. Layer 5 corresponds to the deeper observation well screen interval. Layer 6 extends from the bottom fo the deeper observation well screen to the bottom of the A-Zone. Layers 7, 8, and 9 represent the B-Zone. Three layers are included to allow for upwelling of B-Zone water should that occur. The thicknesses of the A- and B-Zones varied from location to location, but all layers were assumed to be at the same elevation across the model domain. Observation wells are positioned in each model at their measured distances from the pumping well and at the appropriate depth in row 100 of the model. Figure D-2 shows a cross section along row 100 with well locations for the box model for NHE-2.

3.2 MODEL BOUNDAY CONDITIONS

An approximate hydraulic gradient was calculated from interpreted contours at each well location as was the approximate observed water level as presented in the Phase 1 Pre-Design Investigation Report data submital (Amec, 2014). Constant head boundaries are placed at the upgradient (row 1) and downgradient (row 199) extents of the model that created the observed gradient and head at the well location. Constant heads extend to all layers in the model. No attempt was made to recreate vertical head differences that might exist.

Lateral boundaries are defined as no flow (i.e., streamlines with no flux across them). Recharge is not applied over the model domain for the simulation period. No other pumping stresses are assumed to exist within the model domain or to influence the test data.

Pumping stresses are applied to the pumped well as recored in the field. While intended as a constant pumping rate test, variations in pumping were recorded over time. The changes in pumping rate were used to separate the transient model run into a corresponding number of stress periods, some of which were quite short. Time steps within each stress period range from 1 to 40, depending on the length of the stress period; the time step multiplier is 1.2.

3.3 OBSERVATION WELL DATA INPUT

Drawdown data corrected for background trend and barometric pressure influence were converted to head measurements using the selected head at the well location from the Phase 1 Pre-Design water level data. These data were imported into Groundwater Vistas as head targets for the transient simulation runs. Data at each test location reflected 3 to 5 days of testing, including CRD and recovery test intervals.

3.4 INPUT PARAMETERS

Horizontal and vertical K values of 300 feet per day (ft/d) and 3 ft/d were assigned to the B-Zone (model layers 7, 8 and 9) and held constant for all runs. These values are consistent with values assigned in prior modeling and variations are not critical to the current purpose. Initial horizontal and vertical K values assigned to the A-Zone were 100 ft/d and 1 ft/d for model runs for the NHE-2 and NHE-4 pumping test simulations and 200 ft/d and 2 ft/d for the NHE-7 simulation. These horizontal K values were equivalent to anticipated values in the calibrated 2IR groundwater flow model.

3.5 INITIAL HEADS

A steady state run was made for each simulation model to create a starting head matrix for the transient pumping test run simulations. Initial default heads were assigned to all nodes corresponding to the head assigned to the pumping well at time zero. The steady state runs generated the same uniform gradients across the model domain for all layers in the model unique to each simulation. These starting head matrices were imported into each of the respective simulation models.

3.6 TRANSIENT SIMULATION RUNS

Transient runs were made to simulated each of the pumping tests. Stress periods were selected to represent variations in the observed pumping rates. A number of time steps was specified for each of the stress period, the number increasing depending on the length of the stress period. Up to 40 time steps were specified for the longer stress periods. Initial heads were applied from the steady state runs. Table D-1 presents the numbers of stress period, the number of time steps, and the number of observations available for each of the simulation runs.

3.7 OPTIMIZATION RUNS

After a few manual adjustments to approach best-fit residual statistics, the parameter optimization program included with Groundwater Vistas was used to optimize the horizontal and vertical hydraulic conductivity parameter values. That is, only the A-Zone assigned K values were selected for optimization. Other parameters, such as specific yield or storativity might further improve fits, but the primary concern was to arrive at a reasonable horizontal K value to compare to that derived from the pumping test analyses.

Table D-1 summarizes the conditions of the runs, the results of the optimized K values, and the best-fit summary statistics for each of the simulation runs. Figures D-4, D-7, and D-10 show graphs of the comparison of model fit to adjusted heads for the shallow piezometer. Figures D-5, D-8, and D-11 show graphs of the comparison of model fit to adjusted heads for the deep piezometer. Figures D-3, D-6, and D-9 show model fits versus the adjusted observed heads; a perfect fit would be for all points to lie along a 45-degree line (1-to-1 slope). Model fits were relatively good. Observed drawdown data show noise and potential influences not ammenable to adjustment, and the plotted heads are not smooth in sections of the test periods.

The comparison suggested a model horizontal K value of 119 ft/d for NHE-2 versus a CRD test analysis value of 100 ft/d. For NHE-4, the model simulation suggested a horizontal K value of 123 ft/d versus the CRD test analysis value of 135 ft/d. Finally, for NHE-7, the model simulation for the NHE-7 pumping test yielded an estimate of 218 ft/d for horizontal K while the CRD test analysis indicated a value of 203 ft/d. In each case, the model estimated value was a close approximation of the CRD test result.

Fits were generally better for the shallow piezometer. This is intuitive because the shallow piezometer screen correlated with the screened interval of the extraction well. There may be a gradation in K values with depth in the A-Zone, and there may be also a slight vertical gradient in the A-Zone. Hence, the deep piezometers may respond differently than was assumed with a uniform K value for the entire A-Zone thickness.

TABLE D-1

MODEL SIMULATION OF PUMPING TESTS
SUMMARY CONDITIONS AND RESIDUAL STATISTICS

	NHE-2 Test	NHE-4 Test	NHE-7 Test
Stress Periods	3	35	35
Time Steps	80	345	295
Multiplier	1.2	1.2	1.2
Number Observations	2048	672	904
Test duration, days	4.91	3.62	6.07
Residual Mean, ft	0.005	0.02	0.02
Standard deviation	0.059	0.074	0.13
Mean Absolute Residual	0.047	0.06	0.1
Sum of Square of Residuals	7.08	3.99	14.7
Minimum residual, ft	-0.16	-0.3	-0.31
Maximum residual, ft	0.14	0.21	0.35
Range of observations, ft	0.9	1.17	1.39
Normalized std dev	0.065	0.064	0.093
Estimated Horiz K, ft/d	119.2	123.3	218
Estimated Vert K, ft/d	6.2	0.53	20.8

4.0 REFERENCES

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FIGURES

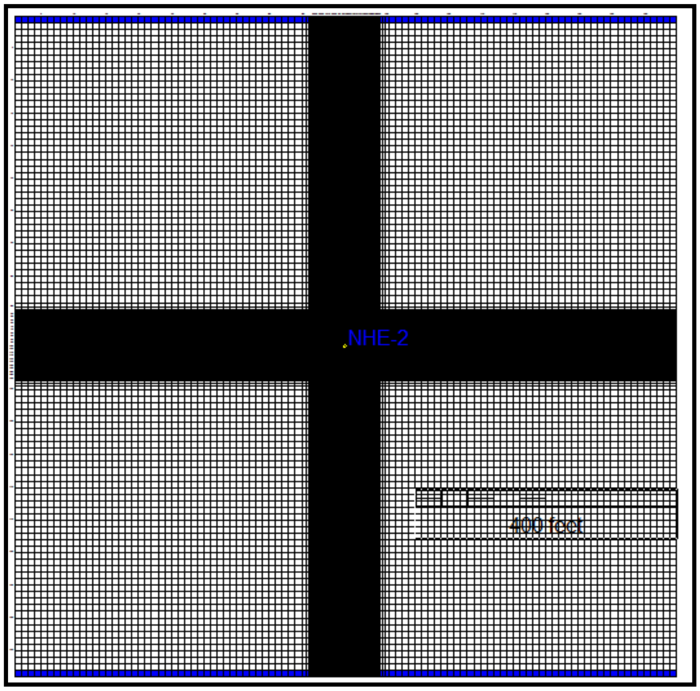

Figure D-1: The grid used for the NHE-2 and other pumping test model simulation runs. The blue rows indicate constant head boundaries used to generate a uniform hydraulic gradient across the model domain under non-pumping conditions. The scale length is 400 feet.

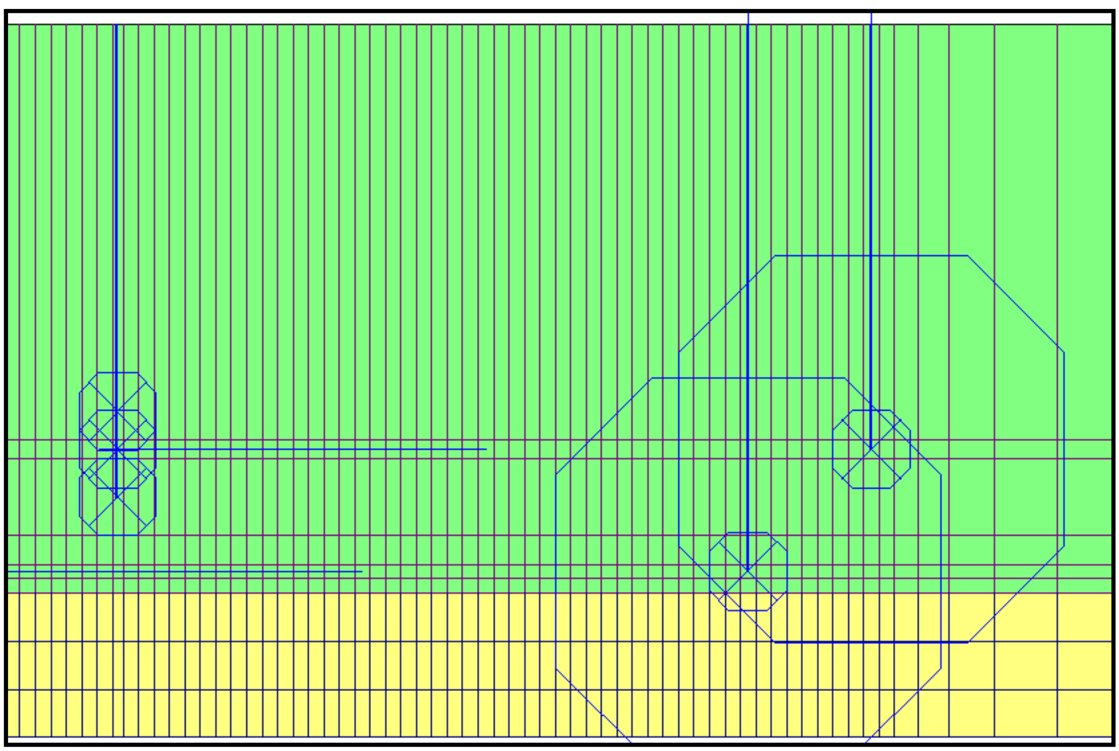

Figure D-2: A cross section along row 100, showing the pumping well to the left in model layer 1, 2 and 3 and observation wells to the right in model layers 2 and 5. The A-Zone is shown as green and the B-Zone as yellow, model layers 7, 8 and 9.

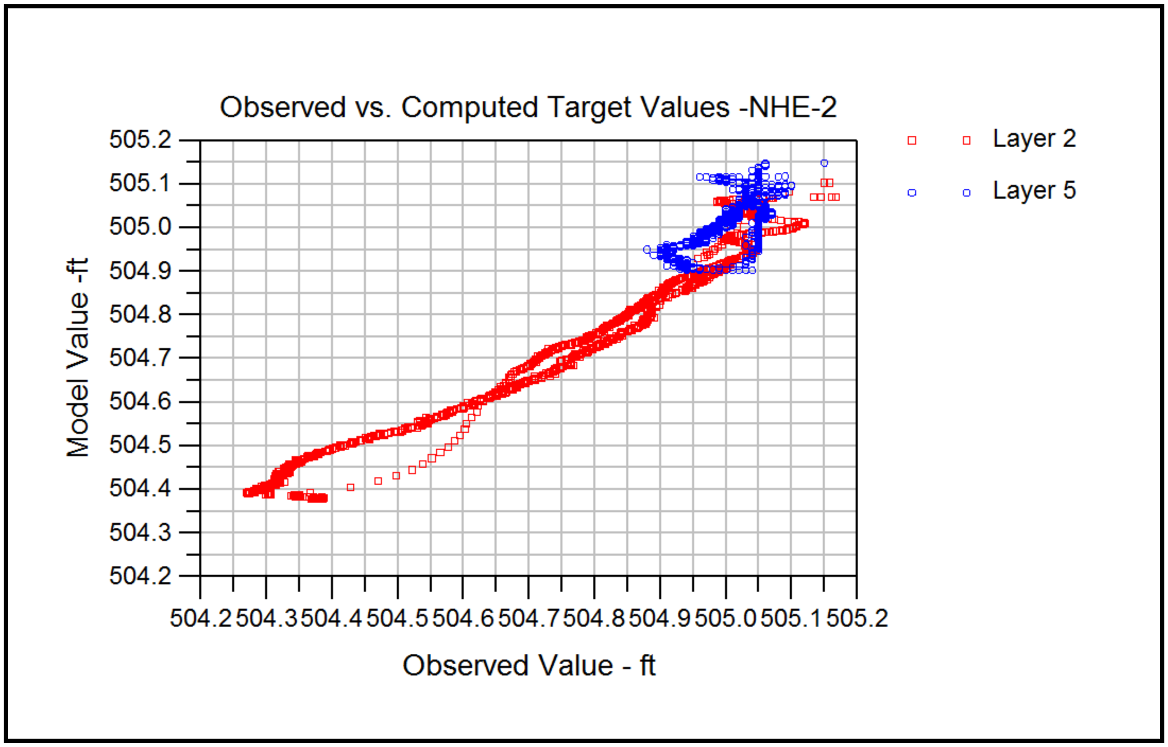

Figure D-3: Modelled pumping test at NHE-2: Observed vs. Computed heads at PZ-NHE-2S (red) and PZ-NHE-2D (blue).

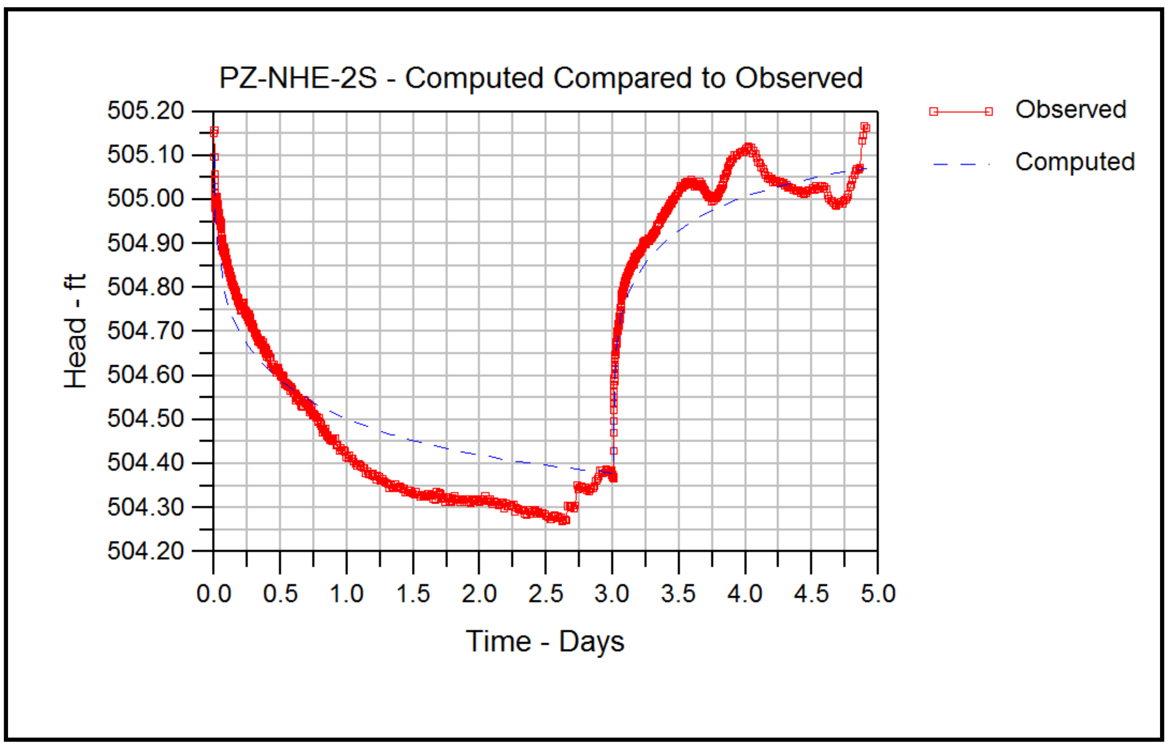

Figure D-4: Modelled output – computed and observed heads at PZ-NHE-2S.

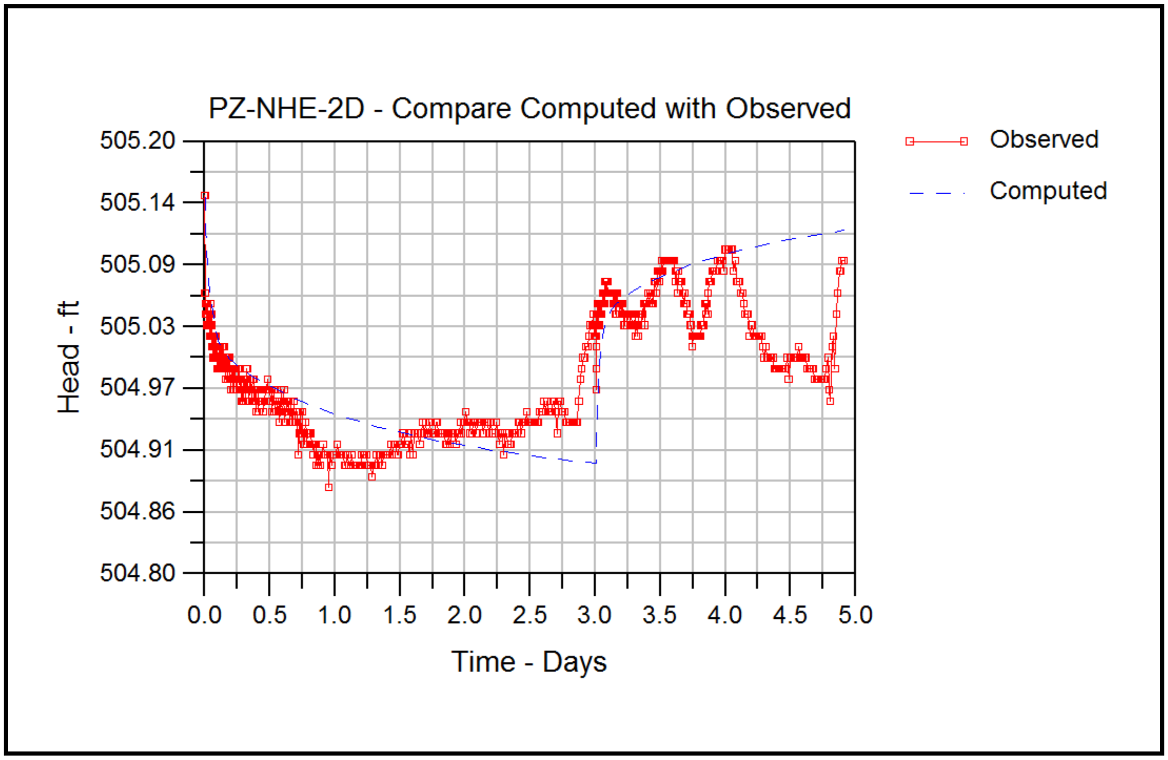

Figure D-5: Modelled output – computed and observed heads at PZ-NHE-2D.

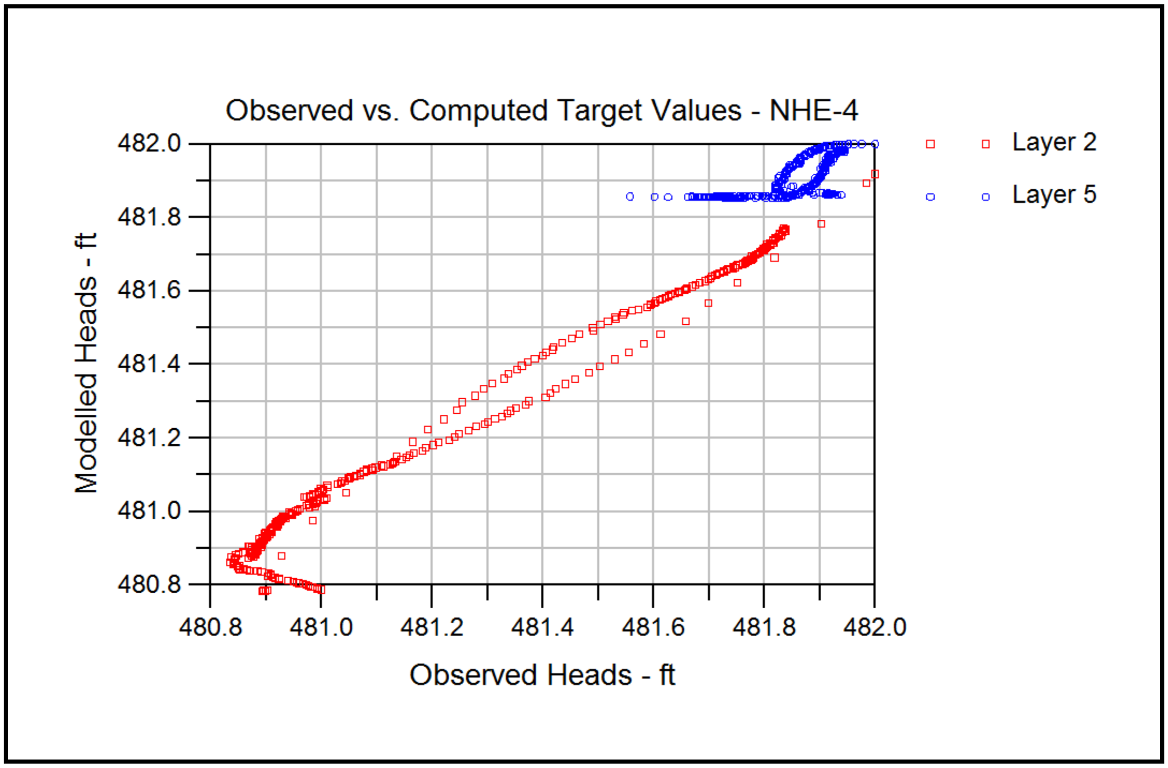

Figure D-6: Modelled pumping test at NHE-4: Observed vs. Computed heads at PZ-NHE-4S (red) and PZ-NHE-4D (blue).

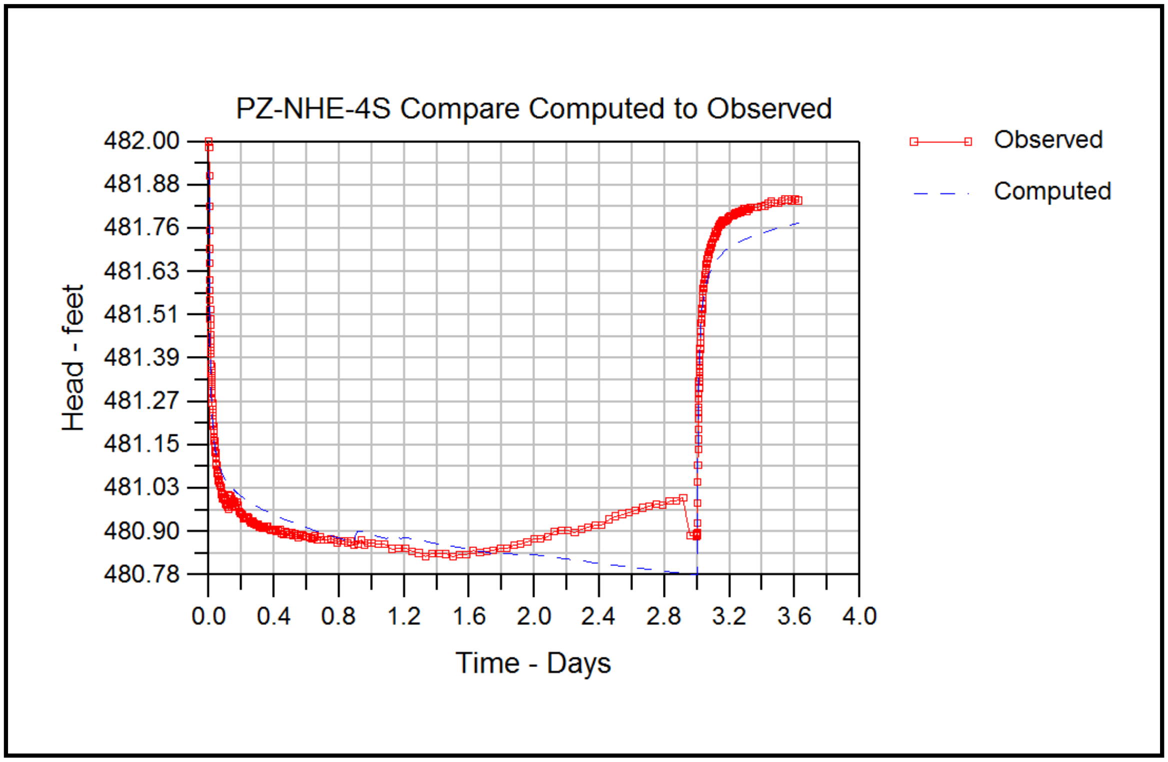

Figure D-7: Modelled output – computed and observed heads at PZ-NHE-4S.

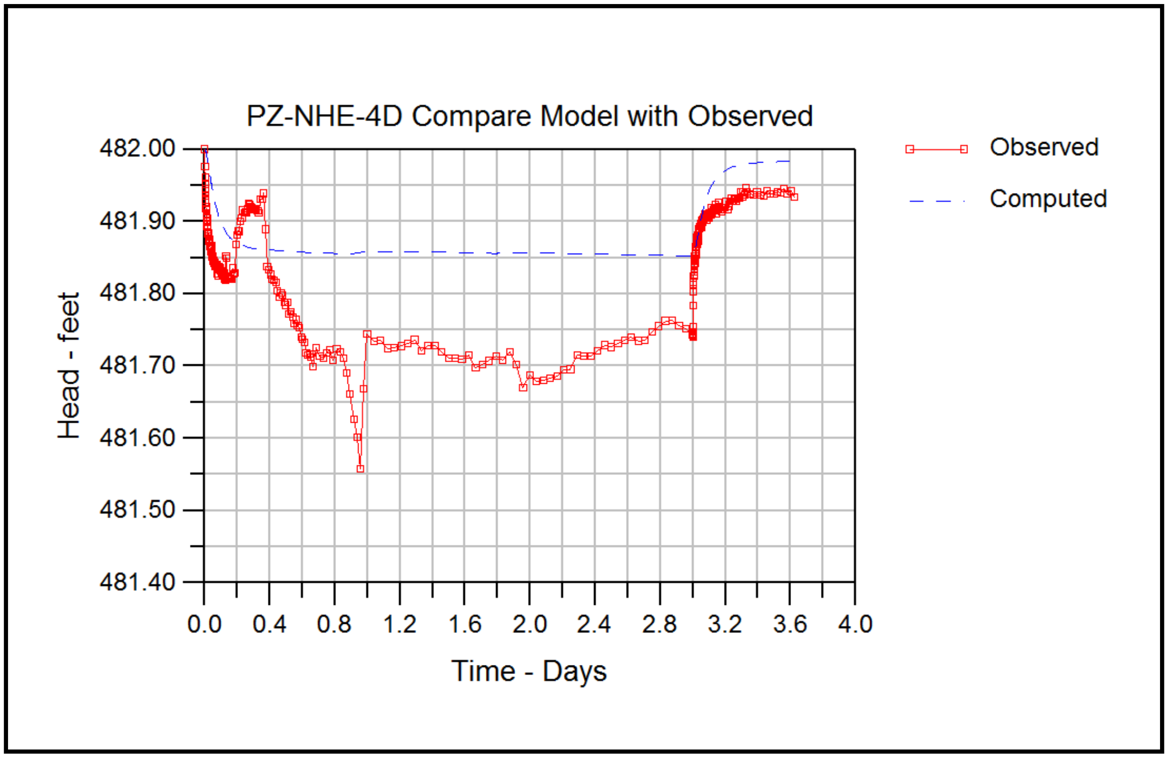

Figure D-8: Modelled output – computed and observed heads at PZ-NHE-4D.

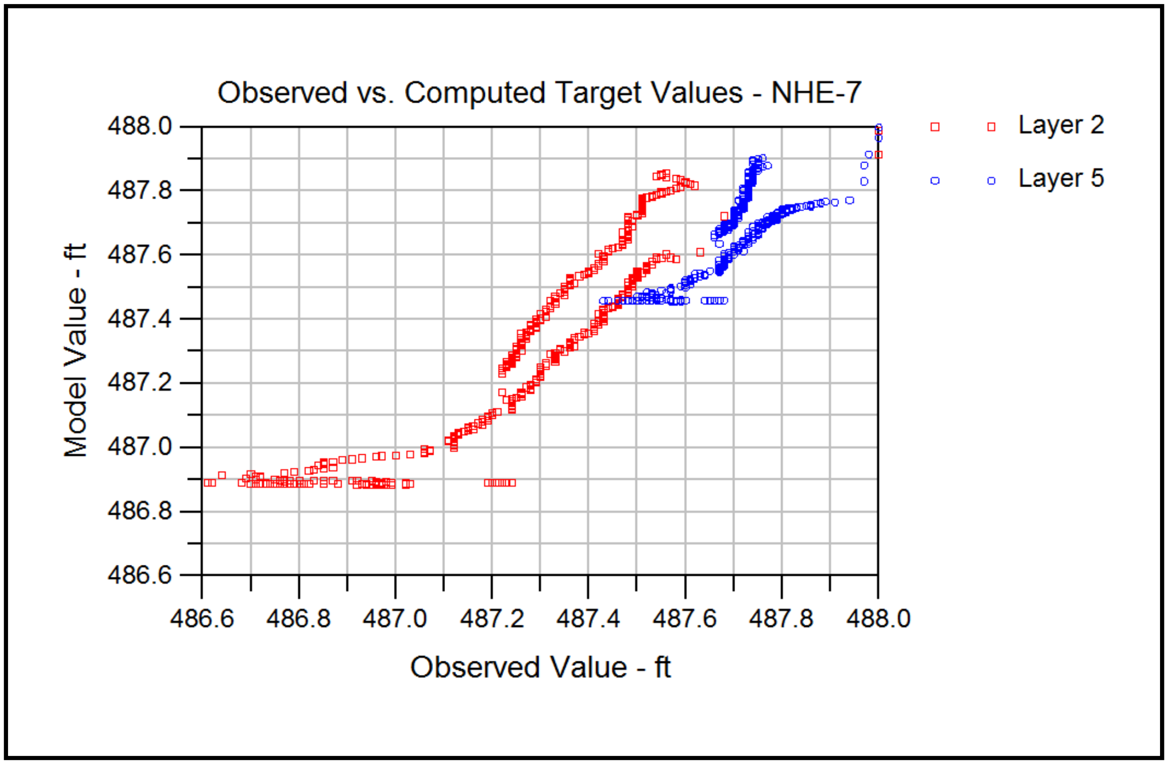

Figure D-9: Modelled pumping test at NHE-7: Observed vs. Computed heads at PZ-NHE-7S (red) and PZ-NHE-7D (blue).

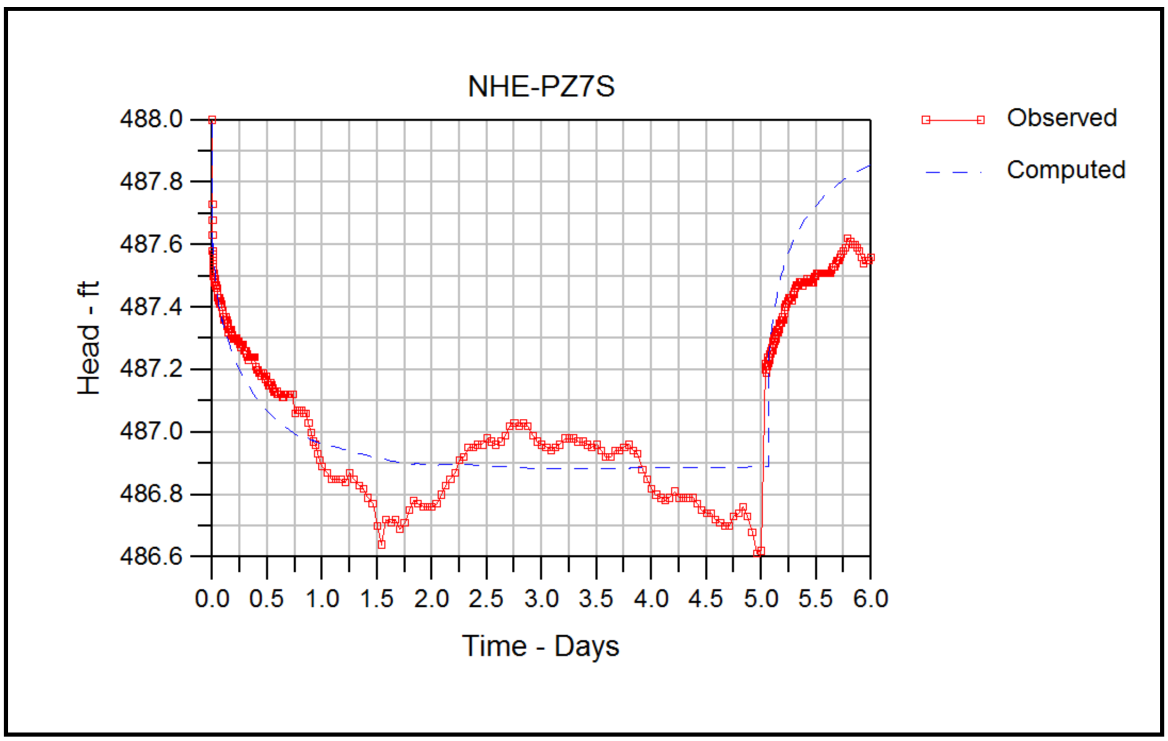

Figure D-10: Modelled output – computed and observed heads at PZ-NHE-7S.

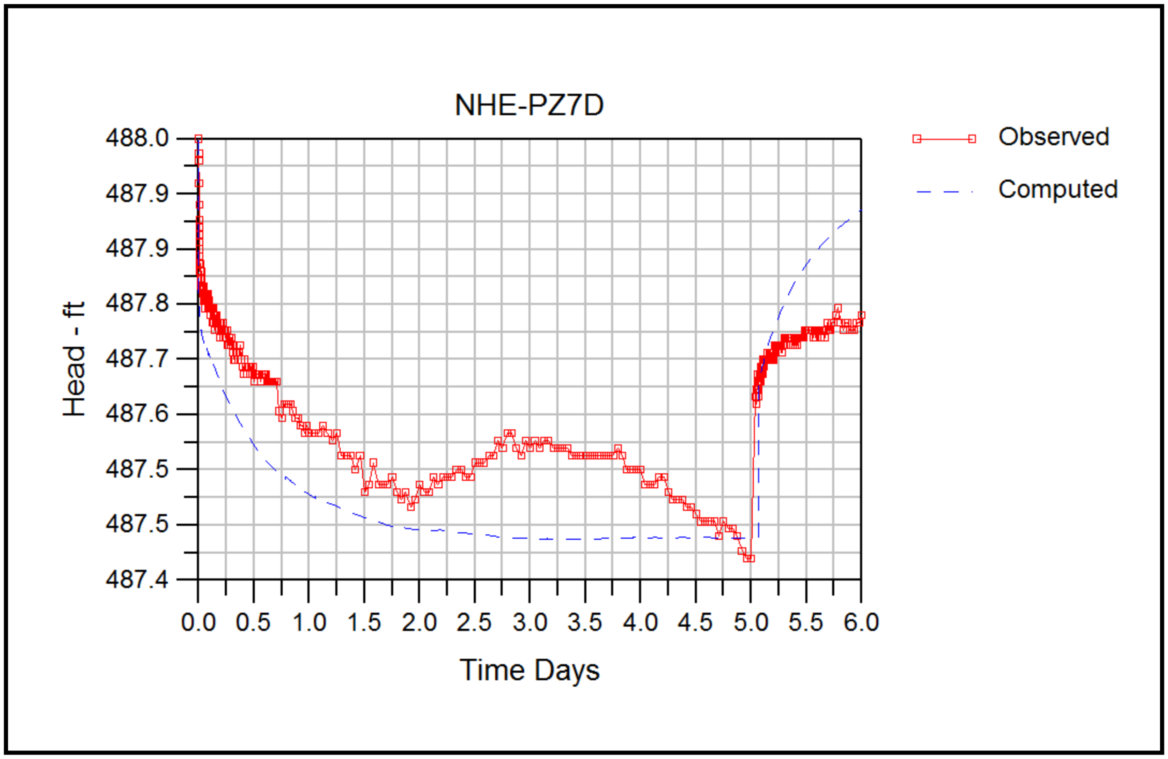

Figure D-11: Modelled output – computed and observed heads at PZ-NHE-7S.

APPENDIX E

Tables of the LADWP March 2015 Pumping and Spreading Projections

APPENDIX E-1

LADWP Projections for Scenario 4B

These draft projections were provided by LADWP (March 2015) solely for the purpose of developing the Groundwater Modeling Memo and are not to be considered in anyway a final projection or plan by LADWP; these draft projection cannot be used or relied upon for other purposes.

TABLE E-1

LADWP PROJECTED PUMPING AND SPREADING RATES (MARCH 2015)
ALTERNATIVE B
North Hollywood Operable Unit
Second Interim Remedy
Groundwater Remediation Design

		NHOU Remedy Pumping and Injection (AFY)				Model Groundwater Pumping, LADWP SFB (AFY)										Model Recharge (AFY)					
Model Year	Calendar Year	NHE Wells	NEW Wells	NH-East	Total (AFY)	North Hollywood East	North Hollywood West	Rinaldi-Toluca	Tujunga	Erwin	Verdugo	Whitnall	Headworks	Pollock	Total (AFY)	TUJUNGA (RCH)	BRANFORD (RCH)	HANSEN (RCH)	LOPEZ (RCH)	PACOIMA (RCH)	TOTAL (AFY)
1	2014-15	-1,377	0	0	-1,377	0	-13,000	-19,200	-23,700	0	0	0	0	-2,178	-59,455	101	460	1,342	544	6,961	9,408
2	2015-16	-1,377	0	0	-1,377	0	-13,000	-19,200	-23,700	-1,000	-1,000	-1,000	0	-2,178	-62,455	1,685	562	11,694	172	10,026	24,139
3	2016-17	-1,377	0	0	-1,377	0	-13,000	-19,200	-23,700	0	0	0	0	-2,178	-59,455	2,664	468	7,487	578	9,109	20,306
4	2017-18	-3,794	-1,129	0	-4,923	0	-13,000	-19,200	-23,700	-1,000	-1,000	-1,000	0	-2,178	-66,001	3,934	547	8,949	536	6,896	20,862
5	2018-19	-3,794	-1,129	0	-4,923	0	-13,000	-19,200	-23,700	0	0	0	0	-2,178	-63,001	11,180	641	28,129	378	26,914	67,242
6	2019-20	-3,794	-1,129	0	-4,923	-10,500	-28,140	-22,165	-29,017	0	0	0	0	-2,178	-92,000	7,306	415	10,549	724	12,328	31,322
7	2020-21	-3,794	-1,129	0	-4,923	-10,500	-28,140	-22,165	-29,017	0	0	0	0	-2,178	-92,000	8,667	345	8,972	363	11,092	29,439
8	2021-22	-3,794	-1,129	0	-4,923	-10,500	-28,140	-22,165	-29,017	0	0	0	0	-2,178	-92,000	19,136	585	35,877	1,086	20,624	77,308
9	2022-23	-3,794	-1,129	0	-4,923	-10,500	-28,140	-22,165	-29,017	0	0	0	0	-2,178	-92,000	5,029	462	12,792	182	9,716	28,181
10	2023-24	-3,794	-1,129	0	-4,923	-10,500	-28,140	-22,165	-29,017	0	0	0	0	-2,178	-92,000	2,222	444	7,164	144	8,291	18,265
11	2024-25	-3,794	-1,129	0	-4,923	-10,500	-28,140	-22,165	-29,017	-3,750	-3,750	-3,750	-3,750	-2,178	-107,000	3,714	932	18,407	518	17,959	41,530
12	2025-26	-3,794	-1,129	0	-4,923	-10,500	-28,140	-22,165	-29,017	-3,750	-3,750	-3,750	-3,750	-2,178	-107,000	1,901	460	10,322	544	15,181	28,408
13	2026-27	-3,794	-1,129	0	-4,923	-10,500	-28,140	-22,165	-29,017	-3,750	-3,750	-3,750	-3,750	-2,178	-107,000	3,485	562	20,674	172	18,246	43,139
14	2027-28	-3,794	-1,129	0	-4,923	-10,500	-28,140	-22,165	-29,017	-3,750	-3,750	-3,750	-3,750	-2,178	-107,000	4,464	468	16,467	578	17,329	39,306
15	2028-29	-3,794	-1,129	0	-4,923	-10,500	-28,140	-22,165	-29,017	-3,750	-3,750	-3,750	-3,750	-2,178	-107,000	5,734	547	17,929	536	15,116	39,862
16	2029-30	-3,794	-1,129	0	-4,923	-10,500	-28,140	-22,165	-44,017	-3,750	-3,750	-3,750	-3,750	-2,178	-122,000	14,780	641	42,339	378	39,604	97,742
17	2030-31	-3,794	-1,129	0	-4,923	-10,500	-28,140	-22,165	-44,017	-3,750	-3,750	-3,750	-3,750	-2,178	-122,000	10,006	415	24,019	724	24,658	59,822
18	2031-32	-3,794	-1,129	0	-4,923	-10,500	-28,140	-22,165	-44,017	-3,750	-3,750	-3,750	-3,750	-2,178	-122,000	11,367	345	22,442	363	23,422	57,939
19	2032-33	-3,794	-1,129	0	-4,923	-10,500	-28,140	-22,165	-44,017	-3,750	-3,750	-3,750	-3,750	-2,178	-122,000	21,836	585	49,347	1,086	32,954	105,808
20	2033-34	-3,794	-1,129	0	-4,923	-10,500	-28,140	-22,165	-44,017	-3,750	-3,750	-3,750	-3,750	-2,178	-122,000	7,729	462	26,262	182	22,046	56,681
21	2034-35	-3,794	-1,129	0	-4,923	-10,500	-33,140	-27,165	-49,017	-3,750	-3,750	-3,750	-3,750	-2,178	-137,000	8,072	444	26,974	144	25,631	61,265
22	2035-36	-3,794	-1,129	0	-4,923	-10,500	-33,140	-27,165	-49,017	-3,750	-3,750	-3,750	-3,750	-2,178	-137,000	8,664	932	29,977	518	27,439	67,530
23	2036-37	-3,794	-1,129	0	-4,923	-10,500	-33,140	-27,165	-49,017	-3,750	-3,750	-3,750	-3,750	-2,178	-137,000	6,851	460	21,892	544	24,661	54,408
24	2037-38	-3,794	-1,129	0	-4,923	-10,500	-33,140	-27,165	-49,017	-3,750	-3,750	-3,750	-3,750	-2,178	-137,000	8,435	562	32,244	172	27,726	69,139
25	2038-39	-3,794	-1,129	0	-4,923	-10,500	-33,140	-27,165	-49,017	-3,750	-3,750	-3,750	-3,750	-2,178	-137,000	9,414	468	28,037	578	26,809	65,306
26	2039-40	-3,794	-1,129	0	-4,923	-10,500	-33,140	-27,165	-49,017	-3,750	-3,750	-3,750	-3,750	-2,178	-137,000	10,684	547	29,499	536	24,596	65,862
27	2040-41	-3,794	-1,129	0	-4,923	-10,500	-33,140	-27,165	-49,017	-3,750	-3,750	-3,750	-3,750	-2,178	-137,000	17,930	641	48,679	378	44,614	112,242
28	2041-42	-3,794	-1,129	0	-4,923	-10,500	-33,140	-27,165	-49,017	-3,750	-3,750	-3,750	-3,750	-2,178	-137,000	13,156	415	30,359	724	29,668	74,322

Note:
These draft projections were provided by LADWP (March 2015) solely for the purpose of developing the Groundwater Modeling Memo and are not to be considered in anyway a final projection or plan by LADWP; these draft projections cannot be used or relied upon for other purposes.

Abbreviation:
AFY = acre feet per year (1,000k AFY is approximately 620 gpm)

amec foster wheeler

APPENDIX E-2

LADWP Projections for the CCC Low Scenario

These draft projections were provided by LADWP (March 2015) solely for the purpose of developing the Groundwater Modeling Memo and are not to be considered in anyway a final projection or plan by LADWP; these draft projections cannot be used or relied upon for other purposes.

TABLE E-2

LADWP PROJECTED PUMPING AND SPREADING RATES (MARCH 2015)
COOPERATIVE CONTAINMENT CONCEPT
North Hollywood Operable Unit
Second Interim Remedy
Groundwater Remediation Design

		NHOU Remedy Pumping (AFY)				Model Groundwater Pumping, LADWP SFB (AFY)										Model Recharge (AFY)					
Model Year	Calendar Year	NHE Wells	NEW Wells	5 CCC Wells	Total CCC Pumping (AFY)	North Hollywood East	North Hollywood West	Rinaldi-Toluca	Tujunga	Erwin	Verdugo	Whitnall	Headworks	Pollock	Total Pumping (AFY)	TUJUNGA (RCH)	BRANFORD (RCH)	HANSEN (RCH)	LOPEZ (RCH)	PACOIMA (RCH)	TOTAL RECHARGE (AFY)
1	2014-15	-1,377	0	0	-1,377	0	-13,000	-19,200	-23,700	0	0	0	0	-2,178	-58,078	101	460	1,342	544	6,961	9,408
2	2015-16	-1,377	0	0	-1,377	0	-13,000	-19,200	-23,700	-1,000	-1,000	-1,000	0	-2,178	-61,078	1,685	562	11,694	172	10,026	24,139
3	2016-17	-1,377	0	0	-1,377	0	-13,000	-19,200	-23,700	0	0	0	0	-2,178	-58,078	2,664	468	7,487	578	9,109	20,306
4	2017-18	-4,923	0	-5,620	-10,543	0	-13,000	-19,200	-23,700	-1,000	-1,000	-1,000	0	-2,178	-61,078	3,934	547	8,949	536	6,896	20,862
5	2018-19	-4,923	0	-5,620	-10,543	0	-13,000	-19,200	-23,700	0	0	0	0	-2,178	-58,078	11,180	641	28,129	378	26,914	67,242
6	2019-20	-4,923	0	-5,620	-10,543	0	-28,140	-22,165	-29,017	0	0	0	0	-2,178	-81,500	7,306	415	10,549	724	12,328	31,322
7	2020-21	-4,923	0	-5,620	-10,543	0	-28,140	-22,165	-29,017	0	0	0	0	-2,178	-81,500	8,667	345	8,972	363	11,092	29,439
8	2021-22	-4,923	0	-5,620	-10,543	0	-28,140	-22,165	-29,017	0	0	0	0	-2,178	-81,500	19,136	585	35,877	1,086	20,624	77,308
9	2022-23	-4,923	0	-5,620	-10,543	0	-28,140	-22,165	-29,017	0	0	0	0	-2,178	-81,500	5,029	462	12,792	182	9,716	28,181
10	2023-24	-4,923	0	-5,620	-10,543	0	-28,140	-22,165	-29,017	0	0	0	0	-2,178	-81,500	2,222	444	7,164	144	8,291	18,265
11	2024-25	-4,923	0	-5,620	-10,543	0	-28,140	-22,165	-29,017	-3,750	-3,750	-3,750	-3,750	-2,178	-96,500	3,714	932	18,407	518	17,959	41,530
12	2025-26	-4,923	0	-5,620	-10,543	0	-28,140	-22,165	-29,017	-3,750	-3,750	-3,750	-3,750	-2,178	-96,500	1,901	460	10,322	544	15,181	28,408
13	2026-27	-4,923	0	-5,620	-10,543	0	-28,140	-22,165	-29,017	-3,750	-3,750	-3,750	-3,750	-2,178	-96,500	3,485	562	20,674	172	18,246	43,139
14	2027-28	-4,923	0	-5,620	-10,543	0	-28,140	-22,165	-29,017	-3,750	-3,750	-3,750	-3,750	-2,178	-96,500	4,464	468	16,467	578	17,329	39,306
15	2028-29	-4,923	0	-5,620	-10,543	0	-28,140	-22,165	-29,017	-3,750	-3,750	-3,750	-3,750	-2,178	-96,500	5,734	547	17,929	536	15,116	39,862
16	2029-30	-4,923	0	-5,620	-10,543	0	-28,140	-22,165	-44,017	-3,750	-3,750	-3,750	-3,750	-2,178	-111,500	14,780	641	42,339	378	39,604	97,742
17	2030-31	-4,923	0	-5,620	-10,543	0	-28,140	-22,165	-44,017	-3,750	-3,750	-3,750	-3,750	-2,178	-111,500	10,006	415	24,019	724	24,658	59,822
18	2031-32	-4,923	0	-5,620	-10,543	0	-28,140	-22,165	-44,017	-3,750	-3,750	-3,750	-3,750	-2,178	-111,500	11,367	345	22,442	363	23,422	57,939
19	2032-33	-4,923	0	-5,620	-10,543	0	-28,140	-22,165	-44,017	-3,750	-3,750	-3,750	-3,750	-2,178	-111,500	21,836	585	49,347	1,086	32,954	105,808
20	2033-34	-4,923	0	-5,620	-10,543	0	-28,140	-22,165	-44,017	-3,750	-3,750	-3,750	-3,750	-2,178	-111,500	7,729	462	26,262	182	22,046	56,681
21	2034-35	-4,923	0	-5,620	-10,543	0	-33,140	-27,165	-49,017	-3,750	-3,750	-3,750	-3,750	-2,178	-126,500	8,072	444	26,974	144	25,631	61,265
22	2035-36	-4,923	0	-5,620	-10,543	0	-33,140	-27,165	-49,017	-3,750	-3,750	-3,750	-3,750	-2,178	-126,500	8,664	932	29,977	518	27,439	67,530
23	2036-37	-4,923	0	-5,620	-10,543	0	-33,140	-27,165	-49,017	-3,750	-3,750	-3,750	-3,750	-2,178	-126,500	6,851	460	21,892	544	24,661	54,408
24	2037-38	-4,923	0	-5,620	-10,543	0	-33,140	-27,165	-49,017	-3,750	-3,750	-3,750	-3,750	-2,178	-126,500	8,435	562	32,244	172	27,726	69,139
25	2038-39	-4,923	0	-5,620	-10,543	0	-33,140	-27,165	-49,017	-3,750	-3,750	-3,750	-3,750	-2,178	-126,500	9,414	468	28,037	578	26,809	65,306
26	2039-40	-4,923	0	-5,620	-10,543	0	-33,140	-27,165	-49,017	-3,750	-3,750	-3,750	-3,750	-2,178	-126,500	10,684	547	29,499	536	24,596	65,862
27	2040-41	-4,923	0	-5,620	-10,543	0	-33,140	-27,165	-49,017	-3,750	-3,750	-3,750	-3,750	-2,178	-126,500	17,930	641	48,679	378	44,614	112,242
28	2041-42	-4,923	0	-5,620	-10,543	0	-33,140	-27,165	-49,017	-3,750	-3,750	-3,750	-3,750	-2,178	-126,500	13,156	415	30,359	724	29,668	74,322

Note:
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Abbreviation:
AFY = acre feet per year (1,000k AFY is approximately 620 gpm)

APPENDIX F

Table of Concentrations used in the 95% UCL Concentration Plots

TABLE F-1

UPPER CONFIDENCE LEVEL SUMMARY
North Hollywood Operable Unit
Second Interim Remedy
Groundwater Remediation Design

Zone	Well Location	TCE			PCE			Chromium (VI)			1,4-Dioxane		
		95%	Reference	Trend[1]	95%	Reference	Trend	95%	Reference	Trend	95%	Reference	Trend
	3830S	8.3	Maximum Detected Value		14	Maximum Detected Value		0.89	Maximum Detected Value		2.8	Maximum Detected Value	
	3831Q	65	Maximum Detected Value		4.7	Maximum Detected Value		3.3	Maximum Detected Value		3.1	Maximum Detected Value	
	3850AB	22	Maximum of Last 3 Points	Decreasing	104.6	95% Student's-t UCL		8.3	Maximum of Last 3 Points	Increasing	1.8	Maximum Detected Value	
	3851M	22	Maximum Detected Value		35	Maximum Detected Value		2.4	Maximum Detected Value		0.83	Maximum Detected Value	
	4899	0.13	Maximum Detected Value		5.6	Maximum Detected Value		1.4	Most Recent Detect		1.5	Most Recent Detect	
	4909C	50	Maximum Detected Value		14	Maximum Detected Value		0.2	Reporting Limit (Non Detects)		0.35	Maximum Detected Value	
	4909F	30	Maximum Detected Value		8.8	Maximum Detected Value		0.85	Maximum Detected Value		1.7	Maximum Detected Value	
	4909FR	64	Maximum Detected Value		46	Maximum Detected Value		1.6	Maximum Detected Value		2.5	Maximum Detected Value	
	4917A	1.8	Maximum Detected Value		1	Maximum Detected Value		1	Reporting Limit (Non Detects)		2	Highest Reporting Limit (Non Detects)	
	4918A	1.9	Maximum Detected Value		0.5	Maximum Detected Value		0.2	Reporting Limit (Non Detects)		16	Maximum Detected Value	
	4919D	15	Maximum Detected Value		1.1	Maximum Detected Value		0.2	Reporting Limit (Only Detect)		1.2	Maximum Detected Value	
	4948	6.7	Maximum Detected Value		65	Maximum Detected Value		1.2	Maximum Detected Value		0.42	Maximum Detected Value	
	4949C	4.7	Maximum Detected Value		3.4	Maximum Detected Value		1.5	Maximum Detected Value		1	Highest Reporting Limit (Non Detects)	
	GW-1	25	Maximum of Last 3 Points	Decreasing	3.71	95% Student's-t UCL		8278	95% Student's-t UCL		48	Maximum Detected Value	
	GW-10	28	Maximum of Last 3 Points	Treated as Increasing[2]	5.731	95% Student's-t UCL		2	Maximum of Last 3 Points	Decreasing	5.464	95% KM (t) UCL	
	GW-11-273	22	Maximum of Last 3 Points	Decreasing	29.4	95% Student's-t UCL		17	Maximum of Last 3 Points	Treated as De	4.818	95% KM (t) UCL	
	GW-11-287	16	Maximum Detected Value		10	Maximum Detected Value		19	Maximum Detected Value		5.5	Maximum Detected Value	
	GW-11-316	35	Maximum of Last 3 Points	Increasing	8.424	95% Student's-t UCL		3.4	Maximum of Last 3 Points	Decreasing	5.348	95% Student's-t UCL	
	GW-12A-284	97.01	95% Student's-t UCL		13.43	95% Student's-t UCL		39	Maximum of Last 3 Points	Decreasing	10.61	95% Student's-t UCL	
	GW-12A-319	37	Maximum Detected Value		5.3	Maximum Detected Value		1.3	Maximum Detected Value		4.2	Maximum Detected Value	
	GW-12B	50	Maximum Detected Value		26	Maximum Detected Value		5.4	Maximum Detected Value		3.5	Maximum Detected Value	
	GW-14A	3.2	Maximum of Last 3 Points (Including NDs)	Decreasing	5.637	95% KM (t) UCL		55	Most Recent Detect	Decreasing	83	Maximum Detected Value	
	GW-14B	6.372	95% Student's-t UCL		9.97	95% Student's-t UCL		74	Maximum of Last 3 Points (Including NDs)	Decreasing	7.2	Maximum Detected Value	
	GW-15	35.56	95% Adjusted Gamma UCL		8.126	95% Student's-t UCL		2.548	95% Student's-t UCL		4.803	95% KM (t) UCL	
	GW-16-277	98.35	95% Student's-t UCL		31.63	95% Student's-t UCL		30.18	95% KM (t) UCL		5.664	95% KM (t) UCL	
	GW-16-317	47	Maximum of Last 3 Points	Increasing	9.3	Maximum of Last 3 Points	Increasing	5.5	Maximum of Last 3 Points	Increasing	4.335	95% KM (t) UCL	
	GW-17-282	770	Maximum of Last 3 Points	Increasing	82	Maximum of Last 3 Points	Increasing	1596	95% Student's-t UCL		13.79	95% KM (BCA) UCL	
	GW-17A	22	Maximum of Last 3 Points	Treated as Increasing[2]	7.05	95% Student's-t UCL		28.14	95% Student's-t UCL		3.672	95% KM (t) UCL	
A	GW-18A	12.34	95% Student's-t UCL		6.523	95% Student's-t UCL		0.965	95% Student's-t UCL		6.332	95% KM (t) UCL	
	GW-19A	170	Maximum of Last 3 Points	Decreasing	11	Maximum of Last 3 Points	Decreasing	66	Maximum of Last 3 Points	Decreasing	4.006	95% KM (t) UCL	
	GW-2	6.595	95% Student's-t UCL		7.651	95% Student's-t UCL		63.77	95% Student's-t UCL		5.742	95% KM (t) UCL	
	GW-20	18.63	95% KM (Chebyshev) UCL		1.758	95% KM (t) UCL		21	Maximum of Last 3 Points	Increasing	22	Maximum of Last 3 Points	Decreasing
	GW-21	1.8	Most Recent Detect		0.887	95% KM (t) UCL		23	Maximum of Last 3 Points	Increasing	15	Maximum of Last 3 Points	Decreasing
	GW-22	30.98	95% Student's-t UCL		6.715	95% Adjusted Gamma UCL		190	Maximum of Last 3 Points	Treated as De	4.949	95% Student's-t UCL	
	GW-23	2.2	Maximum of Last 3 Points	Decreasing	7.74	95% Student's-t UCL		4.249	95% Adjusted Gamma UCL		2.2	Maximum of Last 3 Points	Decreasing
	GW-3	31.75	95% Student's-t UCL		7.261	95% Student's-t UCL		280.9	95% KM (t) UCL		193.4	95% Chebyshev UCL	
	GW-30	0.51	Maximum Detected Value		1	Highest Reporting Limit (Non Detects)		53	Maximum Detected Value		2.1	Maximum Detected Value	
	GW-31	34	Maximum Detected Value		1.9	Maximum Detected Value		140	Maximum Detected Value		18	Maximum Detected Value	
	GW-32	99	Maximum Detected Value		5.3	Maximum Detected Value		1700	Maximum Detected Value		16	Maximum Detected Value	
	GW-33A	24	Maximum Detected Value		13	Maximum Detected Value		84	Maximum Detected Value		6.1	Maximum Detected Value	
	GW-34	2.8	Maximum Detected Value		1.7	Maximum Detected Value		19	Maximum Detected Value		5	Maximum Detected Value	
	GW-4	5.839	95% Student's-t UCL		0.854	95% KM (t) UCL		31.81	95% Student's-t UCL		34	Maximum Detected Value	
	GW-5	1.8	Maximum of Last 3 Points		1.17	95% KM (t) UCL		19	Maximum of Last 3 Points	Increasing	38	Maximum Detected Value	
	GW-6	3.373	95% Student's-t UCL		4.126	95% Student's-t UCL		1.4	Maximum of Last 3 Points	Decreasing	3	Maximum of Last 3 Points	Decreasing
	GW-7	18	Maximum of Last 3 Points	Decreasing	6.9	Maximum of Last 3 Points	Decreasing	5.9	Maximum of Last 3 Points	Decreasing	7.248	95% KM (t) UCL	
	GW-8	6.2	Maximum of Last 3 Points	Increasing	6.068	95% Student's-t UCL		1.022	95% Student's-t UCL		8	Maximum Detected Value	
	GW-9	19	Maximum of Last 3 Points	Increasing	4.871	95% Student's-t UCL		0.906	95% Student's-t UCL		6.7	Maximum Detected Value	
	LA1-CW03R	28	Maximum Detected Value		180	Maximum Detected Value		0.19	Reporting Limit (Non Detects)		3.3	Maximum Detected Value	
	LA1-CW09	16	Maximum of Last 3 Points	Decreasing	70.3	95% Student's-t UCL		1.2	Maximum Detected Value		1.6	Maximum Detected Value	
	LA-MW1	0.5	Reporting Limit (only Detect)		1.2	Maximum Detected Value		0.90	Maximum Detected Value		1.9	Highest Reporting Limit	
	LA-MW2	0.5	Reporting Limit (only Detect)		1.3	Maximum Detected Value		0.81	Maximum Detected Value		0.47	Maximum Detected Value	
	LA-MW3	0.5	Reporting Limit (only Detect)		0.85	Maximum Detected Value		0.82	Maximum Detected Value		2.1	Highest Reporting Limit	
	LB5-CW03	46	Maximum Detected Value		27	Maximum Detected Value		2.3	Maximum Detected Value		5	Maximum Detected Value	
	LB6-CW09	9.8	Maximum Detected Value		79	Maximum Detected Value		0.1	Most Recent Detect		0.64	Highest Detected Value	
	LB6-CW10	34	Maximum Detected Value		140	Maximum Detected Value		0.82	Maximum Detected Value		1.3	Maximum Detected Value	
	LB6-CW16	11	Maximum of Last 3 Points	Treated as Increasing[2]	27	Maximum of Last 3 Points	Increasing	1.284	95% Student's-t UCL		0.41	Only Detected Value	
	LB6-CW17	5	Maximum Detected Value		56	Maximum Detected Value		1.7	Maximum Detected Value		0.67	Maximum Detected Value	

TABLE F-1

UPPER CONFIDENCE LEVEL SUMMARY
North Hollywood Operable Unit
Second Interim Remedy
Groundwater Remediation Design

Zone	Well Location	TCE			PCE			Chromium (VI)			1,4-Dioxane		
		95%	Reference	Trend[1]	95%	Reference	Trend	95%	Reference	Trend	95%	Reference	Trend
	LC1-CW03	0.614	95% KM (t) UCL		6.4	Maximum of Last 3 Points	Decreasing	0.669	95% Student's-t UCL		1.7	Maximum Detected Value	
	LC1-CW06	260	Maximum of Last 3 Points	Decreasing	14	Maximum of Last 3 Points	Decreasing	0.823	95% Student's-t UCL		1.2	Maximum Detected Value	
	LC1-CW08	0.9	Maximum of Last 3 Points	Decreasing	13	Maximum of Last 3 Points	Decreasing	0.59	Highest Detected Value		3	Maximum Detected Value	
	NH-C01-325	12	Maximum Detected Value		61	Maximum Detected Value		0.25	Maximum Detected Value		100	Highest Reporting Limit (Non Detects)	
	NH-C02-220	8.9	Maximum Detected Value		0.44	Maximum Detected Value		2.9	Maximum Detected Value		0.5	Highest Reporting Limit (Non Detects)	
	NH-C05-320	20	Maximum Detected Value		4.1	Maximum Detected Value		1.4	Maximum Detected Value		3	Maximum Detected Value	
	NH-C07-300	6.3	Maximum Detected Value		2.3	Maximum Detected Value		21	Maximum Detected Value		28	Maximum Detected Value	
	NH-C08-295	3	Maximum Detected Value		4.6	Maximum Detected Value		0.72	Maximum Detected Value		1.5	Maximum Detected Value	
	NH-C09-310	73	Maximum Detected Value		32	Maximum Detected Value		1.8	Maximum Detected Value		110	Maximum Detected Value	
	NH-C10-280	35	Maximum Detected Value		41	Maximum Detected Value		20	Maximum Detected Value		2.3	Maximum Detected Value	
	NH-C11-295	120	Maximum Detected Value		110	Maximum Detected Value		1.7	Maximum Detected Value		2.9	Maximum Detected Value	
	NH-C12-280	56	Maximum Detected Value		6.9	Maximum Detected Value		0.76	Maximum Detected Value		3.8	Maximum Detected Value	
	NH-C13-385	9.6	Maximum Detected Value		1.1	Maximum Detected Value		1.4	Maximum Detected Value		0.33	Highest Reporting Limit (Non Detects)	
	NH-C14-250	8.1	Maximum Detected Value		27	Maximum Detected Value		2.7	Maximum Detected Value		0.5	Highest Reporting Limit (Non Detects)	
	NH-C15-240		No Data			No Data			No Data			No Data	
	NH-C15-330	33	Maximum Detected Value		4	Maximum Detected Value		3.4	Maximum Detected Value		0.57	Maximum Detected Value	
	NH-C16-320	7.8	Maximum Detected Value		12	Maximum Detected Value		0.73	Maximum Detected Value		2.5	Maximum Detected Value	
	NH-C16-390	22	Maximum Detected Value		3	Maximum Detected Value		0.53	Maximum Detected Value		4.3	Maximum Detected Value	
	NH-C17-255	110	Maximum Detected Value		6.3	Maximum Detected Value		3.7	Maximum Detected Value		5.5	Maximum Detected Value	
	NH-C17-339	11	Maximum Detected Value		3.7	Maximum Detected Value		1.9	Maximum Detected Value		1.6	Maximum Detected Value	
	NH-C18-270	11	Maximum Detected Value		6.2	Maximum Detected Value		2.9	Maximum Detected Value		0.8	Maximum Detected Value	
	NH-C18-365	100	Maximum of Last 3 Points	Decreasing	6.4	Maximum of Last 3 Points	Decreasing	69.23	95% Student's-t UCL		3.021	95% Student's-t UCL	
	NH-C19-290	88.78	95% Student's-t UCL		3.102	95% KM (t) UCL		2.4	Maximum Detected Value		0.35	Maximum Detected Value	
	NH-C19-360	76.63	95% Student's-t UCL		3.15	95% Student's-t UCL		2.5	Maximum Detected Value		1.8	Maximum Detected Value	
	NH-C20-380	46	Maximum Detected Value		1.6	Maximum Detected Value		0.78	Maximum Detected Value		1.8	Maximum Detected Value	
	NH-C21-260	44	Maximum Detected Value		5.019	95% Student's-t UCL		39.42	95% Student's-t UCL		1.1	Highest Detected Value	
	NH-C21-340	95	Maximum Detected Value	Increasing	3.101	95% Student's-t UCL		17.2	95% Student's-t UCL		2.075	95% KM (t) UCL	
	NH-C22-360	7.3	Maximum Detected Value		1.02	Maximum Detected Value		0.63	Maximum Detected Value		0.8	Highest Reporting Limit (Non Detects)	
	NH-C23-310	3.972	95% Student's-t UCL		3.076	95% Student's-t UCL		1	Maximum Detected Value		4	Maximum Detected Value	
A	NH-C23-400	17	Maximum Detected Value		3.9	Maximum Detected Value		0.37	Maximum Detected Value		2.1	Maximum Detected Value	
	NH-C24-305	0.84	Maximum Detected Value		4.9	Maximum Detected Value		1.5	Maximum Detected Value		0.89	Maximum Detected Value	
	NH-C25-290	2.3	Maximum Detected Value		24	Maximum Detected Value		0.57	Maximum Detected Value		4.5	Maximum Detected Value	
	NH-C26-310	31	Maximum Detected Value		1.7	Maximum Detected Value		2.3	Maximum Detected Value		0.48	Maximum Detected Value	
	NH-C27-290	82	Maximum Detected Value		5.7	Maximum Detected Value		1.5	Maximum Detected Value		2.6	Maximum Detected Value	
	NH-C28-290	110	Maximum Detected Value		29	Maximum Detected Value		42	Maximum Detected Value		47	Maximum Detected Value	
	NHE-1	71	Maximum Detected Value		4.8	Maximum Detected Value		0.24	Maximum Detected Value		3.2	Maximum Detected Value	
	NHE-2	225	Maximum of Last 3 Points	Decreasing	41.7	Maximum of Last 3 Points	Increasing	64.3	Maximum of Last 3 Points	Decreasing	3.38	Maximum of Last 3 Points	Increasing
	NHE-3	183	Maximum of Last 3 Points	Increasing	12.4	Maximum of Last 3 Points		171	Maximum of Last 3 Points	Increasing	5.52	Maximum of Last 3 Points	Increasing
	NHE-4	11.3	Maximum of Last 3 Points	Decreasing	2.3	Maximum of Last 3 Points	Decreasing	5.39	Maximum of Last 3 Points	Increasing	1.01	Maximum of Last 3 Points	Decreasing
	NHE-5	10.5	Maximum Detected Value		9.04	Maximum Detected Value		0.66	Maximum Detected Value		2.28	Maximum Detected Value	
	NHE-6	8.9	Maximum of Last 3 Points	Decreasing	4.68	Maximum of Last 3 Points	Decreasing	3.205	95% Student's-t UCL		0.9	Most Recent Detect	
	NHE-7	5.7	Maximum of Last 3 Points	Decreasing	7.6	Maximum of Last 3 Points	Increasing	0.993	95% KM (t) UCL		1.18	Most Recent Detect	Decreasing
	NHE-8	67.5	Maximum of Last 3 Points	Treated as Increasing[2]	5.6	Maximum of Last 3 Points	Decreasing	1.42	Maximum of Last 3 Points	Increasing	1.71	Maximum of Last 3 Points	Increasing
	NH-MW-06		No Data			No Data		0.52	Maximum Detected Value		35.9	Maximum Detected Value	
	NH-VPB-05	78	Maximum Detected Value		3.6	Maximum Detected Value		4.4	Maximum Detected Value		0.9	Highest Reporting Limit (Non Detects)	
	NH-VPB-06	4.5	Maximum Detected Value		2	Maximum Detected Value		1.2	Maximum Detected Value		100	Highest Reporting Limit (Non Detects)	
	NH-VPB-07	1.2	Maximum Detected Value		3.1	Maximum Detected Value		0.97	Maximum Detected Value		100	Highest Reporting Limit (Non Detects)	
	NH-VPB-08		No Data			No Data			No Data			No Data	
	NH-VPB-09	0.48	Maximum Detected Value		2.4	Maximum Detected Value		0.02	Reporting Limit (Non Detects)			No Data	
	PA1-MW1	40	Maximum Detected Value		77	Maximum Detected Value		1.47	Maximum Detected Value		1.10	Maximum Detected Value	
	PA1-MW2	44	Maximum Detected Value		68	Maximum Detected Value		2.6	Maximum Detected Value		0.65	Maximum Detected Value	
	PA1-MW3	16	Maximum Detected Value		65	Maximum Detected Value		1.7	Maximum Detected Value		2.60	Maximum Detected Value	
	PA1-MW4	13	Maximum Detected Value		43	Maximum Detected Value		1.5	Maximum Detected Value		1.00	Highest Reporting Limit (Non Detects)	
	PA1-MW5	33	Maximum Detected Value		56	Maximum Detected Value		2.2	Maximum Detected Value		0.83	Maximum Detected Value	
	PA1-MW6	35	Maximum Detected Value		72	Maximum Detected Value		3	Maximum Detected Value		1.70	Maximum Detected Value	
	HP-MW-01	85	Maximum Detected Value		130	Maximum Detected Value		4.8	Maximum Detected Value		1	Highest Reporting Limit (Non Detects)	
	HP-MW-02	11	Maximum Detected Value		28	Maximum Detected Value		0.2	Highest Reporting Value (Non Detects)		440	Maximum Detected Value	
	HP-MW-03	1.5	Maximum Detected Value		6.8	Maximum Detected Value		1.4	Maximum Detected Value		99	Maximum Detected Value	
	HP-MW-04	2.7	Maximum Detected Value		13	Maximum Detected Value		0.81	Maximum Detected Value		590	Maximum Detected Value	

TABLE F-1

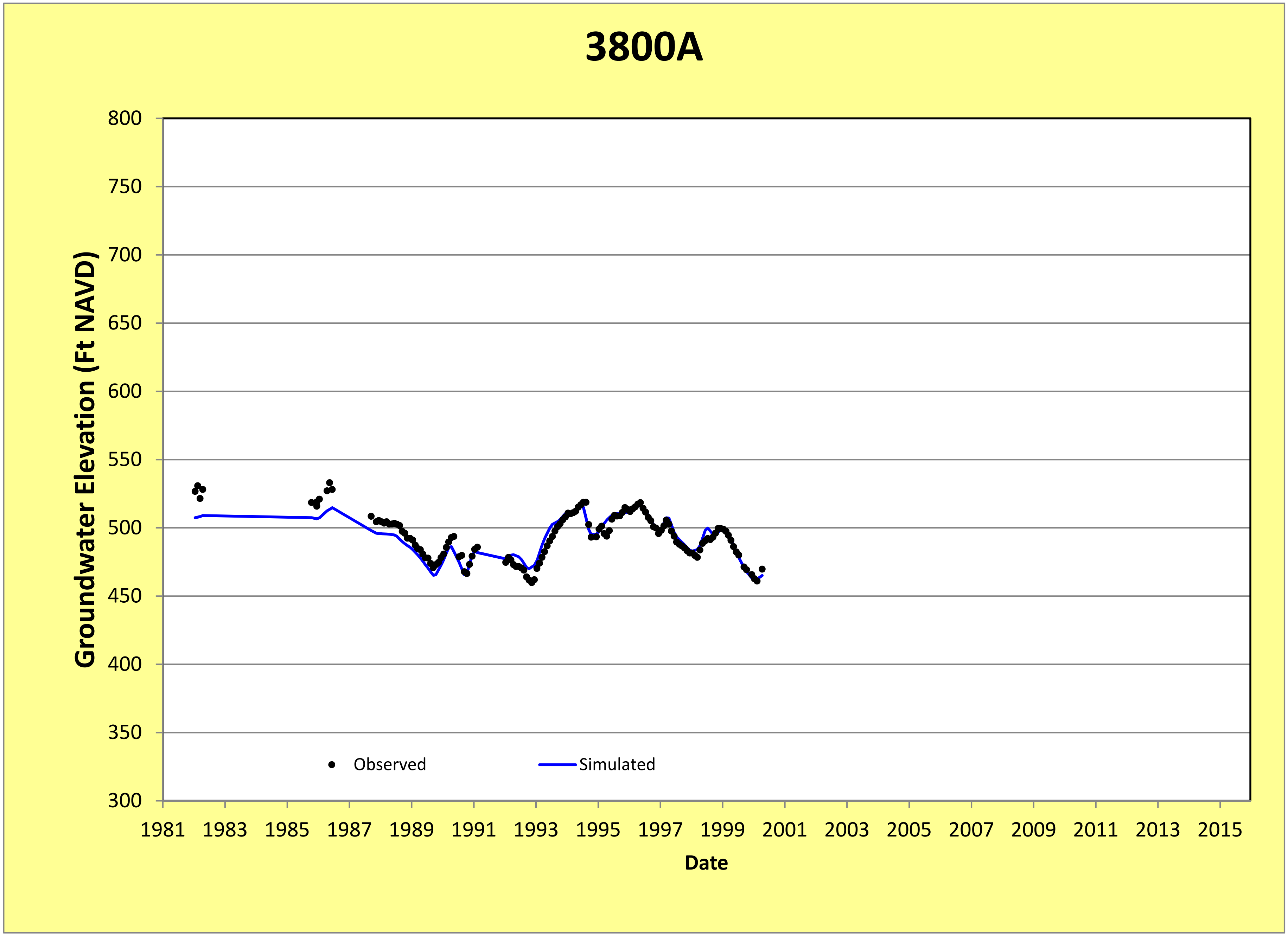
UPPER CONFIDENCE LEVEL SUMMARY
North Hollywood Operable Unit
Second Interim Remedy
Groundwater Remediation Design

Zone	Well Location	TCE			PCE			Chromium (VI)			1,4-Dioxane		
		95%	Reference	Trend[1]	95%	Reference	Trend	95%	Reference	Trend	95%	Reference	Trend
	3830Q	1	Maximum Detected Value		1.3	Maximum Detected Value		1	Reporting Limit (Non Detects)		0.37	Maximum Detected Value	
	3851N	0.91	Maximum Detected Value		2.3	Maximum Detected Value		0.26	Maximum Detected Value		1	Highest Reporting Limit (Non Detects)	
	4909C	18	Maximum Detected Value		0.52	Maximum Detected Value		0.41	Maximum Detected Value		0.49	Maximum Detected Value	
	4918A	2.6	Maximum Detected Value		0.5	Highest Reporting Limit (Non Detects)		0.2	Reporting Limit (Non Detects)		8.7	Maximum Detected Value	
	GW-11-352	56	Maximum of Last 3 Points	Increasing	4.569	95% Student's-t UCL		20	Maximum of Last 3 Points	Increasing	3.271	95% KM (t) UCL	
	GW-11-407	0.51	Maximum of Last 3 Points (Including NDs)		0.886	95% KM (t) UCL		19	Maximum of Last 3 Points	Increasing	1.2	Only Detected Value	
	GW-12A-349	5.3	Maximum of Last 3 Points	Increasing	11	Highest Reporting Limit (Non Detects)		0.596	95% Student's-t UCL		2.238	95% KM (t) UCL	
	GW-16-347	43	Maximum of Last 3 Points	Increasing	5.568	95% Student's-t UCL		9.2	Maximum of Last 3 Points		2.864	95% KM (t) UCL	
	GW-18B	15	Maximum of Last 3 Points	Increasing	0.66	Maximum of Last 3 Points	Increasing	0.421	95% KM (t) UCL		0.63	Maximum of Last 3 Points	Increasing
	GW-19B	3.534	95% KM (Chebyshev) UCL		0.42	Maximum of Last 3 Points	Increasing	0.614	95% KM (t) UCL		0.52	Only Detected Value	
	GW-33B	31	Maximum Detected Value		2.9	Maximum Detected Value		0.49	Maximum Detected Value		0.92	Maximum Detected Value	
	LA1-CW02	5.9	Maximum Detected Value		73	Maximum Detected Value		0.02	Reporting Limit (Non Detects)		0.65	Maximum Detected Value	
	LA1-CW05	2.5	Maximum of Last 3 Points	Decreasing	40	Maximum of Last 3 Points	Decreasing	0.3	Maximum Detected Value		2	Maximum Detected Value	
	LB5-CW02	1	Highest Reporting Limit (No Detects)		5	Maximum of Last 3 Points	Decreasing	0.15	Most Recent Detect		1.57	95% KM (t) UCL	
	LB6-CW08	5.3	Maximum Detected Value		41	Maximum Detected Value		1	Reporting Limit (Non Detects)		0.55	Maximum Detected Value	
	LB6-CW14	11	Maximum Detected Value		120	Maximum Detected Value		0.62	Maximum of Last 3 Points		1.122	95% Student's-t UCL	
	LC1-CW02	0.5	Reporting Limit (Only Detect)		1.645	95% Student's-t UCL		1	Highest Reporting Value (Non Detects)		1	Maximum Detected Value	
	LC1-CW05	0.5	Highest Reporting Limit (No Detects)		0.751	95% Student's-t UCL		1	Highest Reporting Value (Non Detects)		0.51	Maximum Detected Value	
B	NH-C01-450	2.8	Maximum Detected Value		0.98	Maximum Detected Value		0.24	Maximum Detected Value		2.2	Maximum Detected Value	
	NH-C02-325	4.9	Maximum Detected Value		2.5	Maximum Detected Value		1.1	Maximum Detected Value		1	Maximum Detected Value	
	NH-C03-380	0.77	Maximum Detected Value		1.9	Maximum Detected Value		2.7	Maximum Detected Value		1	Highest Reporting Limit (Non Detects)	
	NH-C05-460	4	Maximum Detected Value		0.5	Maximum Detected Value		0.12	Maximum Detected Value		0.07	Reporting Limit (Only Detect)	
	NH-C10-360	4.4	Maximum Detected Value		5.1	Maximum Detected Value		1.5	Maximum Detected Value		1.7	Maximum Detected Value	
	NH-C12-360	5.389	95% KM (t) UCL		3.522	95% Student's-t UCL		1.009	95% Student's-t UCL		2	Maximum Detected Value	
	NH-C15-330	7.3	Maximum Detected Value		0.26	Maximum Detected Value		1.5	Maximum Detected Value		0.23	Highest Reporting Limit (Non Detects)	
	NH-C13-385	10	Maximum Detected Value		0.98	Maximum Detected Value		2.6	Maximum Detected Value		0.35	Maximum Detected Value	
	NH-C16-390	25	Maximum Detected Value		2	Maximum Detected Value		0.47	Maximum Detected Value		1.3	Maximum Detected Value	
	NH-C17-339	4.3	Maximum Detected Value		1.5	Maximum Detected Value		1.3	Maximum Detected Value		1.2	Maximum Detected Value	
	NH-C18-365	71	Maximum Detected Value		2.8	Maximum Detected Value		11	Maximum Detected Value		3.3	Maximum Detected Value	
	NH-C19-360	50.67	95% Student's-t UCL		3.004	95% Student's-t UCL		1.4	Maximum Detected Value		2.3	Maximum Detected Value	
	NH-C20-380	71	Maximum Detected Value		1.6	Maximum Detected Value		0.45	Maximum Detected Value		1.3	Maximum Detected Value	
	NH-C21-340	65	Maximum Detected Value		1.7	Maximum Detected Value		21	Maximum Detected Value		2.1	Maximum Detected Value	
	NH-C22-460	7.2	Maximum Detected Value		1.02	Maximum Detected Value		0.15	Maximum Detected Value		0.8	Highest Reporting Limit (Non Detects)	
	NH-C23-400	86.64	95% Student's-t UCL		2.711	95% KM (t) UCL		0.45	Maximum Detected Value		2.2	Maximum Detected Value	
	NH-C24-410	0.42	Maximum Detected Value		1	Maximum Detected Value		0.45	Maximum Detected Value			No Data	
	NH-C26-385	100	Maximum Detected Value		4.4	Maximum Detected Value		1.1	Maximum Detected Value		2.8	Maximum Detected Value	
	NH-VPB-02	8.6	Maximum Detected Value		3.4	Maximum Detected Value		3.4	Maximum Detected Value		0.9	Highest Reporting Limit (Non Detects)	

Notes:
1. Trends are based on Mann-Kendall trend test with a 95% confidence level.
2. Trend treated as increasing based on p-value for the Mann-Kendall test statistic and/or trend in most recent data points.
3. Trend treated as decreasing based on p-value for the Mann-Kendall test statistic and/or trend in most recent data points.

APPENDIX G

Hydrographs of Observed and Simulated Groundwater Elevations for Observations Wells



3800A
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
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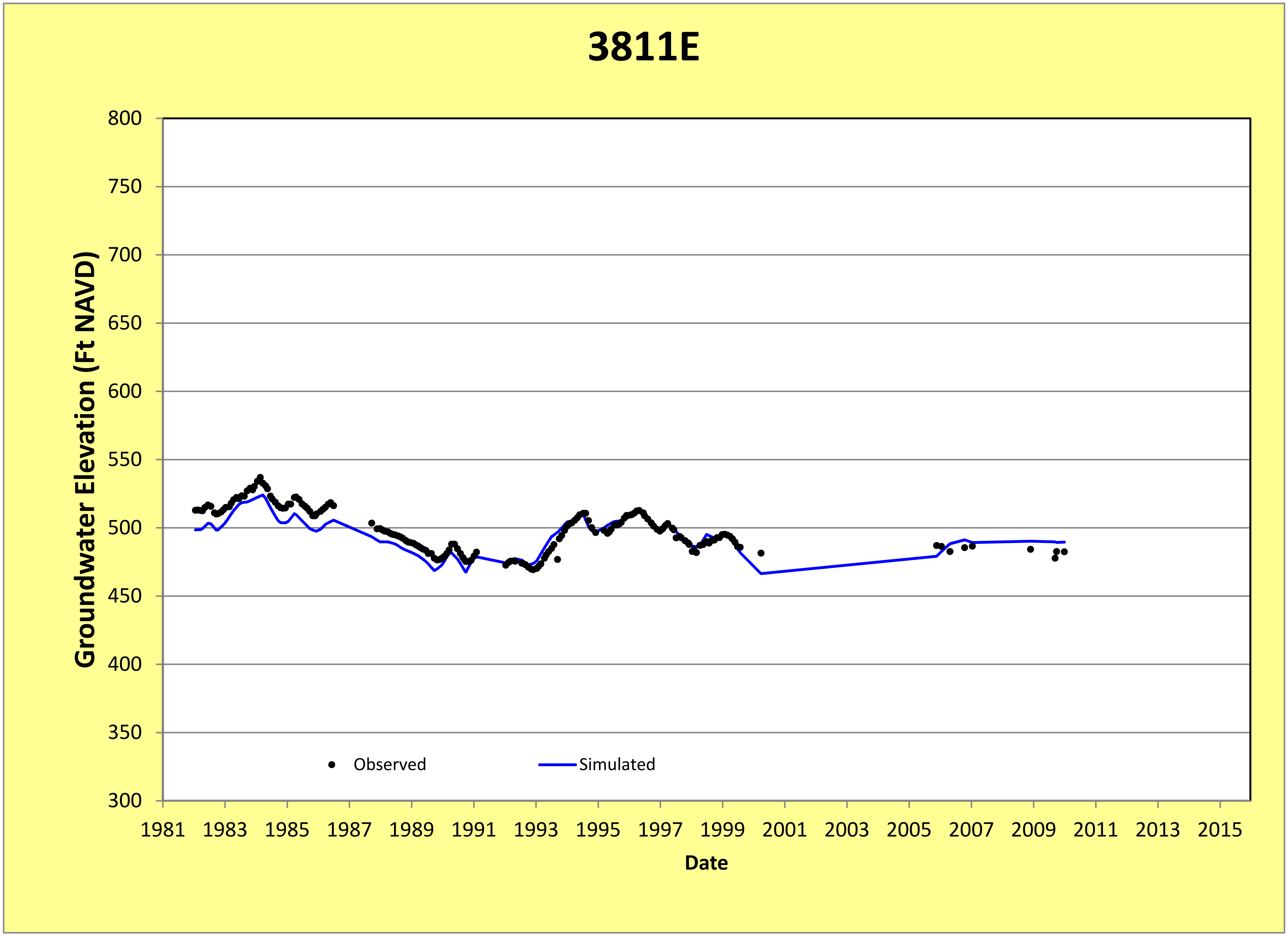
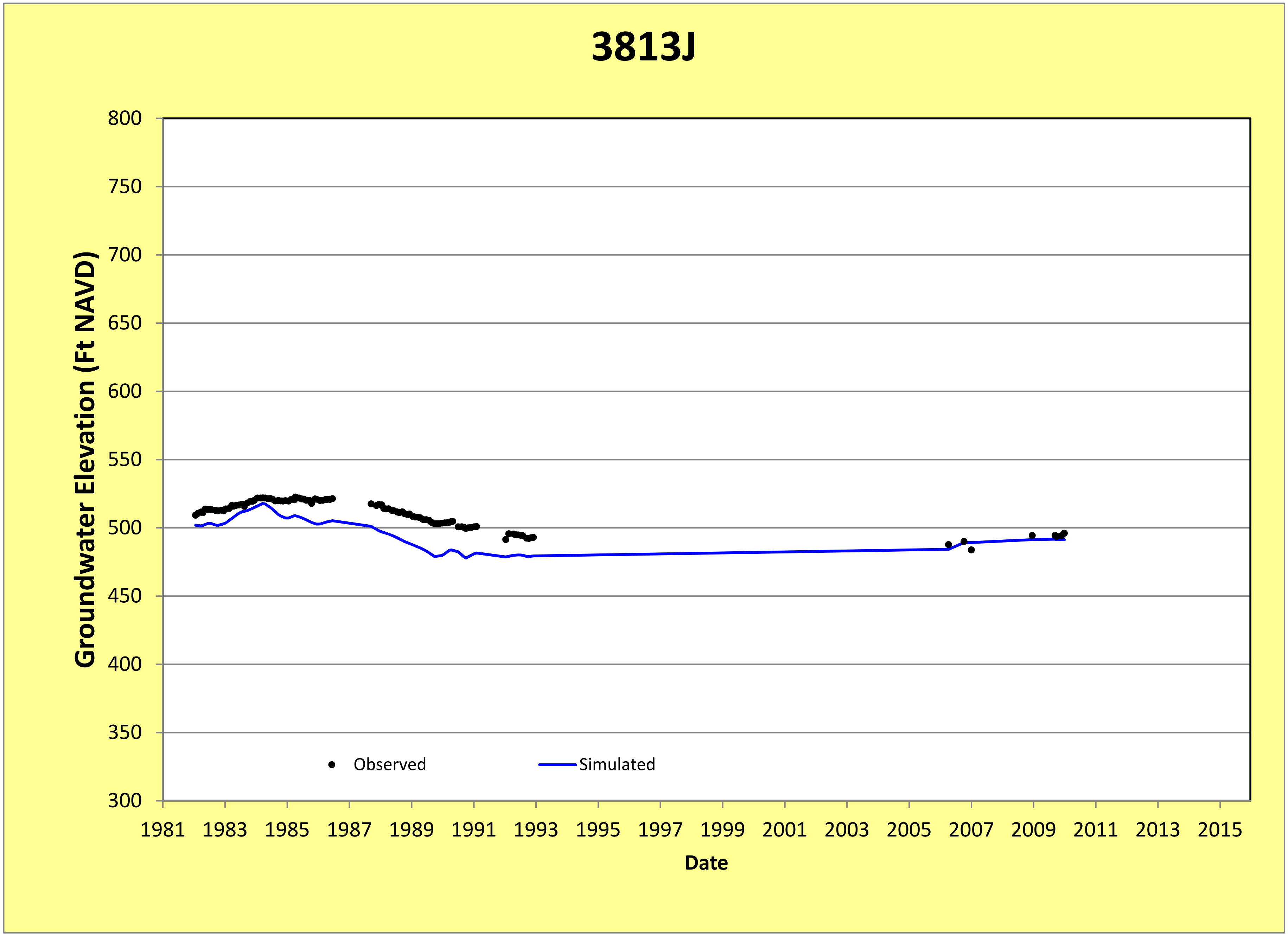
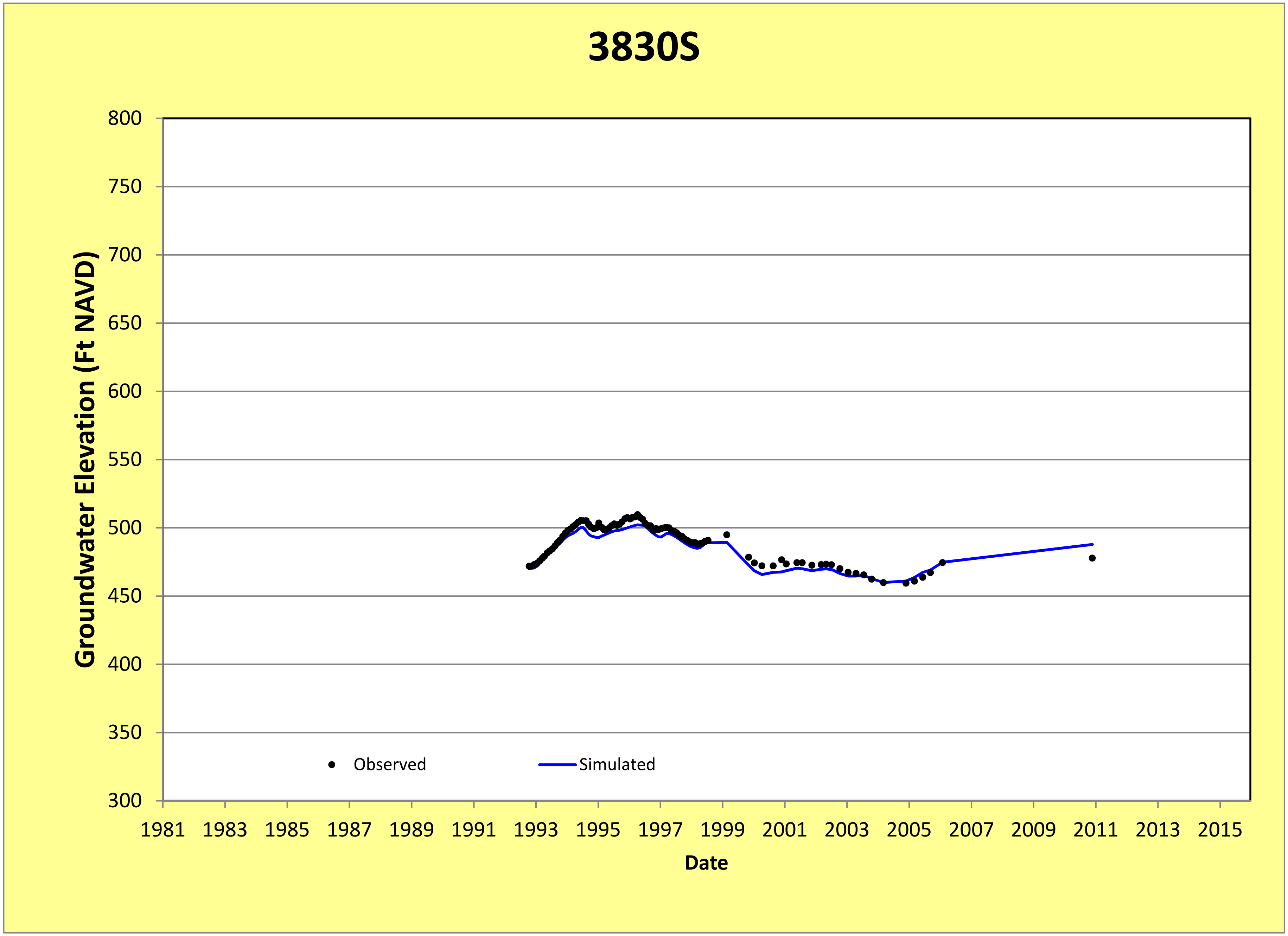
2005
2007
2009
2011
2013
2015
Date


3811E
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date


3813J
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date



3830S
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
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1993
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2011
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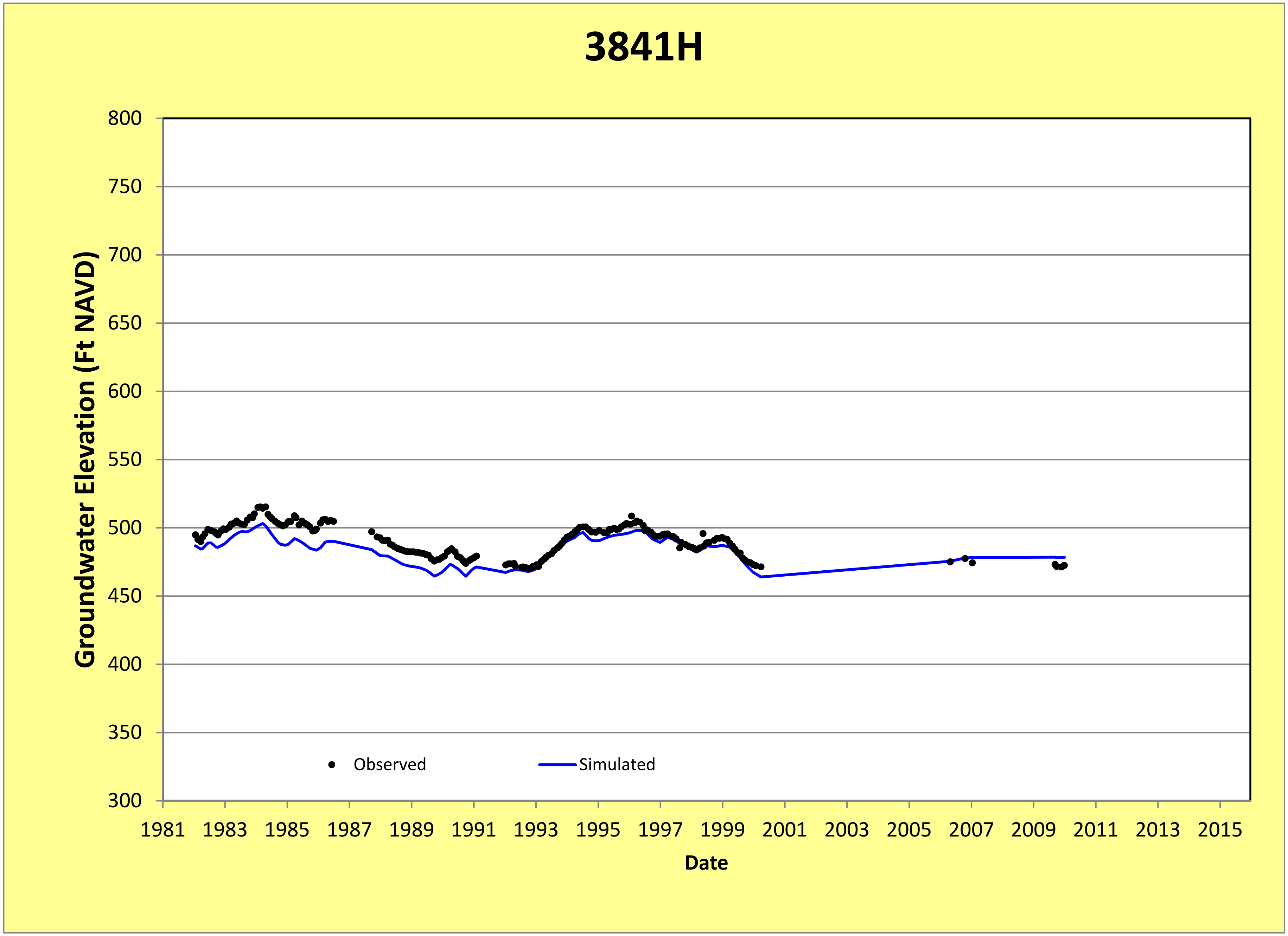
2015
Date



3841H
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
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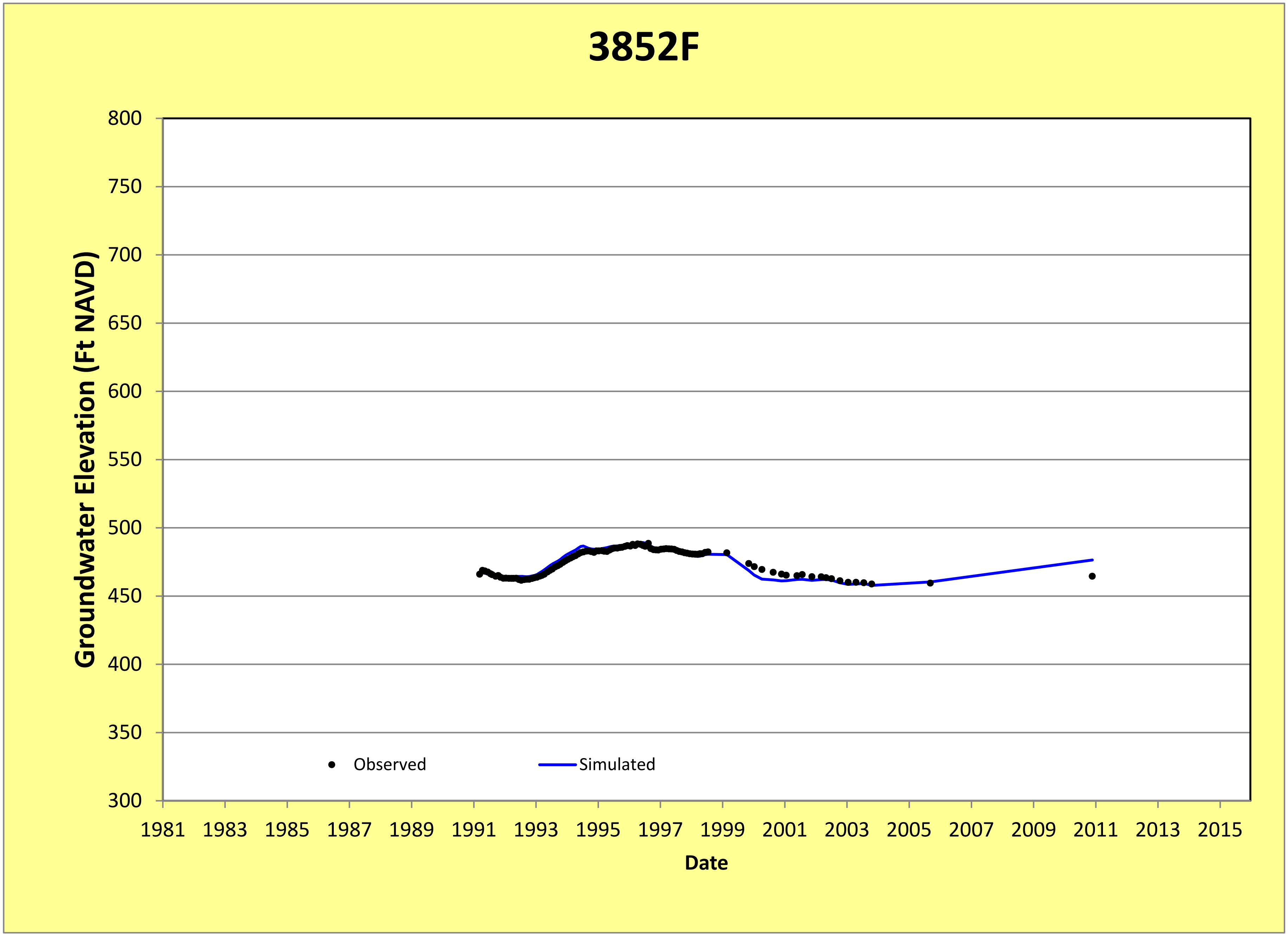
2007
2009
2011
2013
2015
Date


3852F
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
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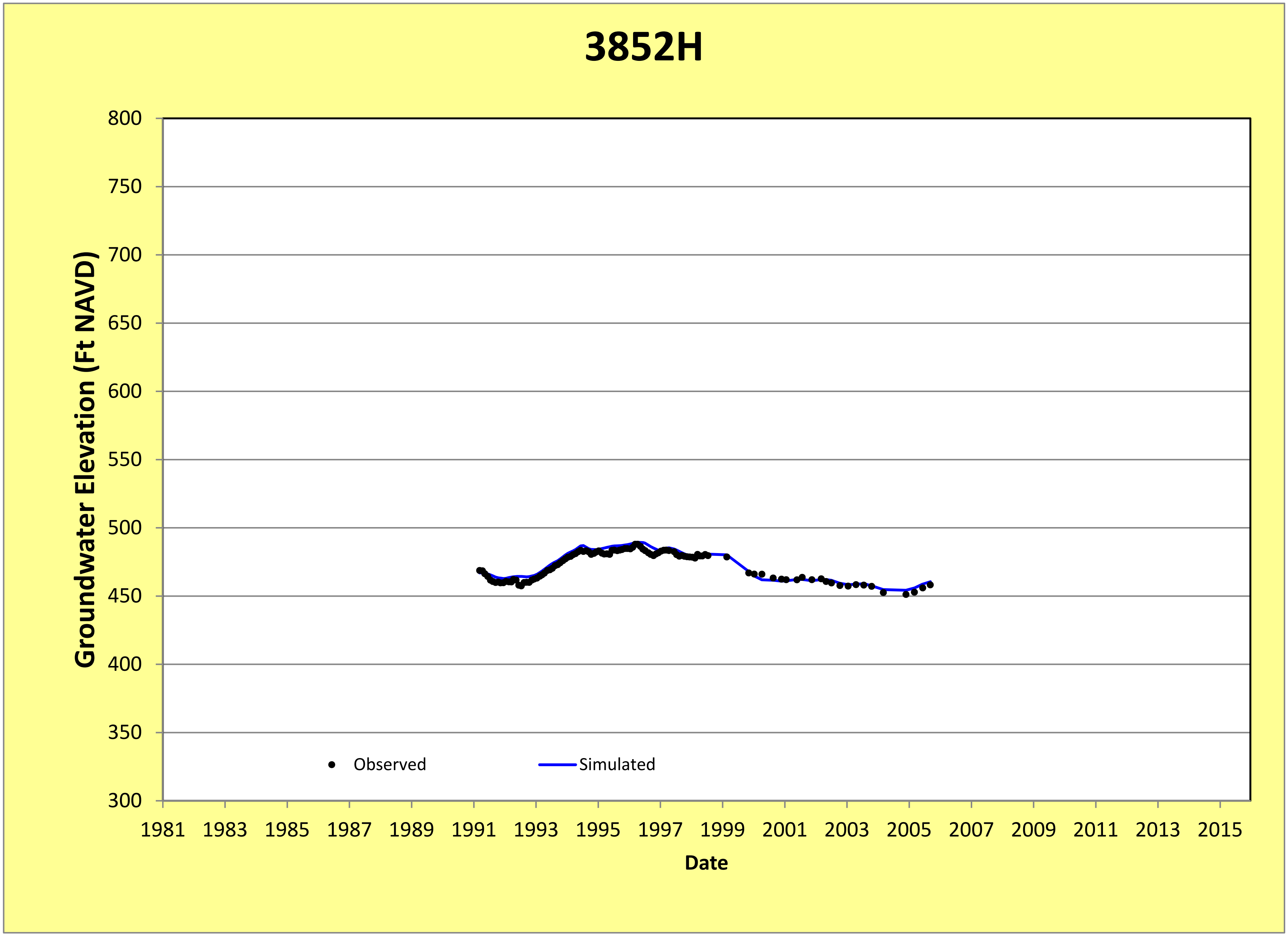
2011
2013
2015
Date


3852H
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
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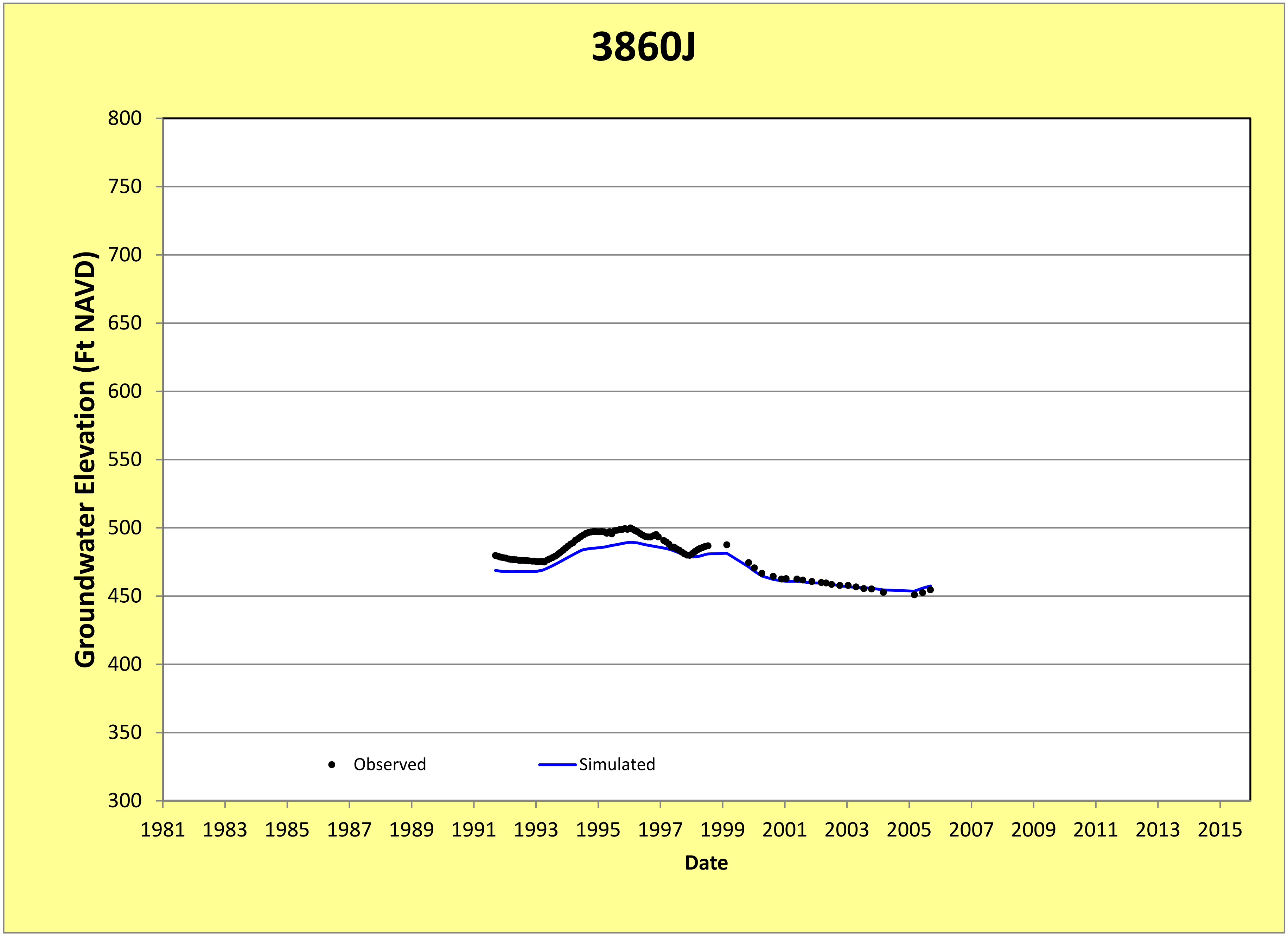
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated


3860J
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
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1987
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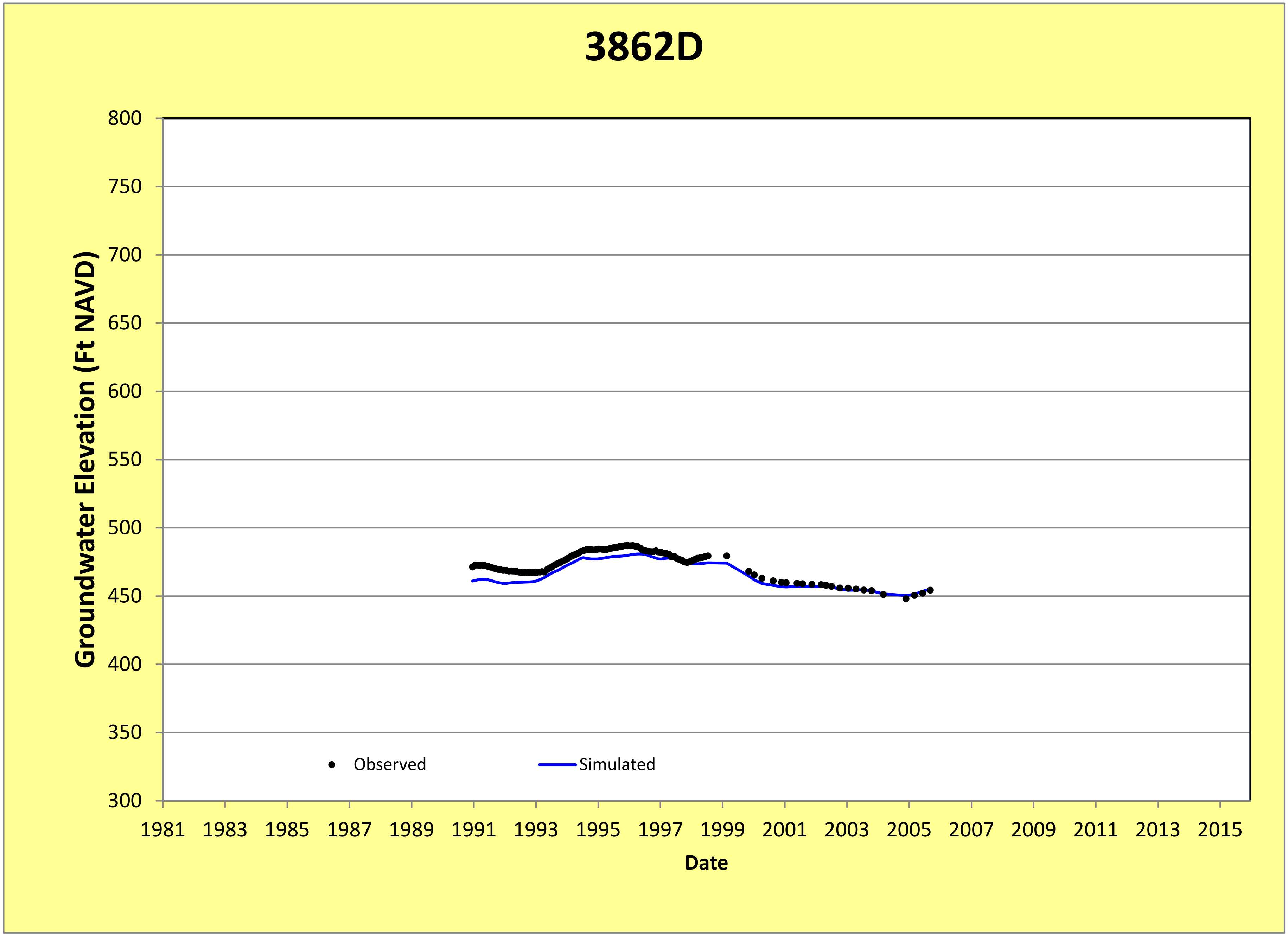
2011
2013
2015
Date



3862D
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
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1989
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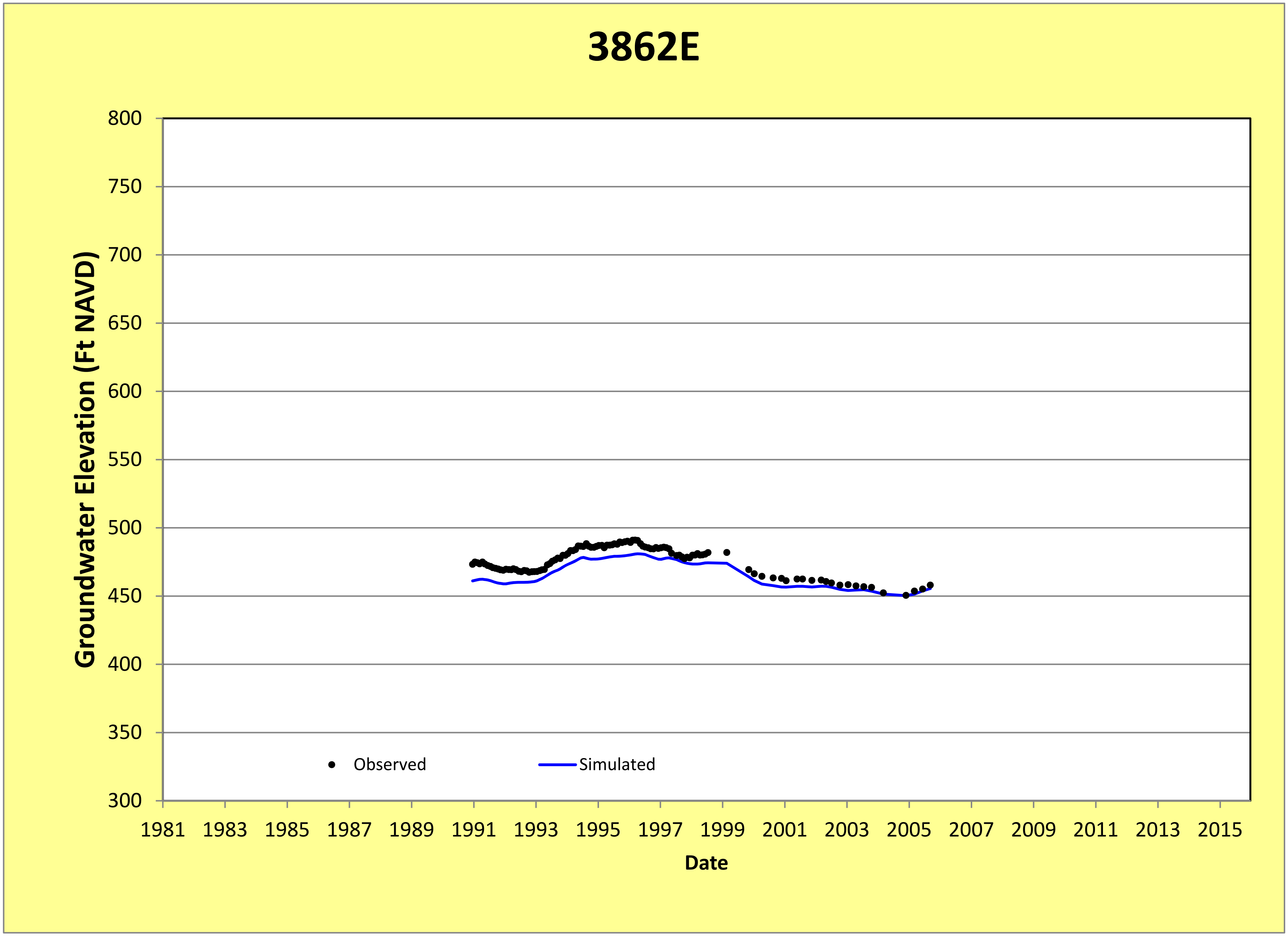
2009
2011
2013
2015
Date


3862E
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
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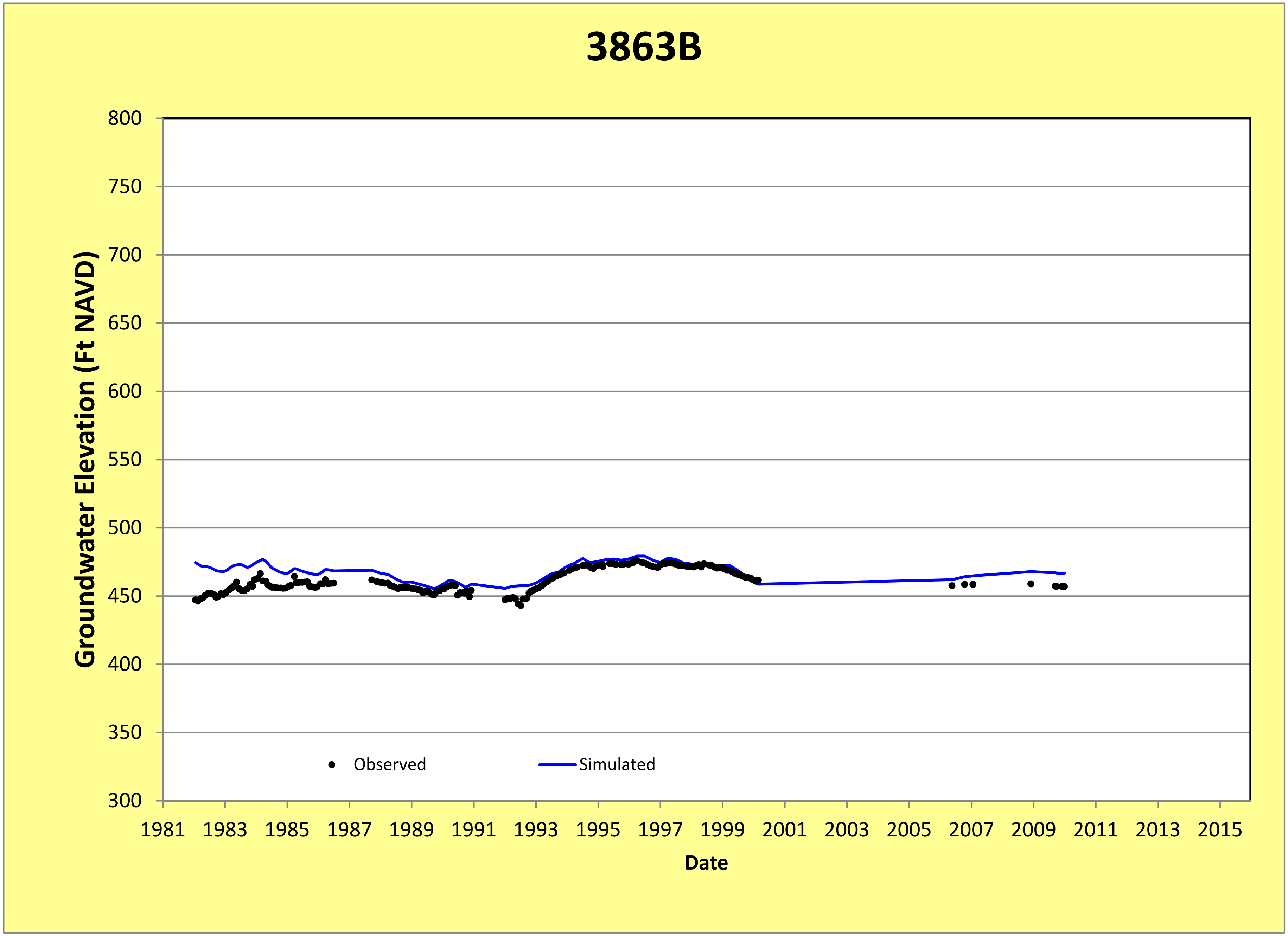
2009
2011
2013
2015
Date



3863B
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
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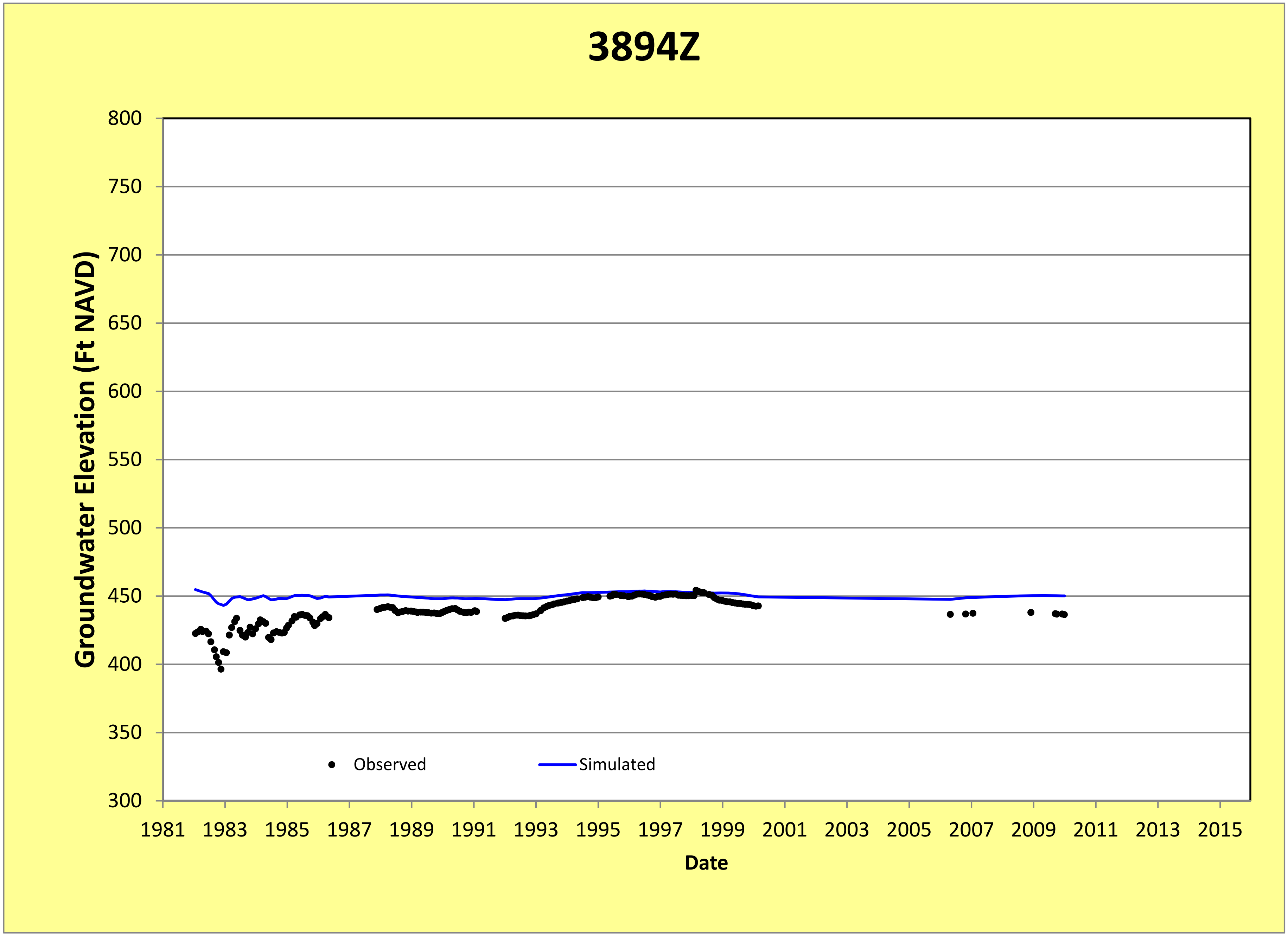
2007
2009
2011
2013
2015
Date



3894Z
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
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2011
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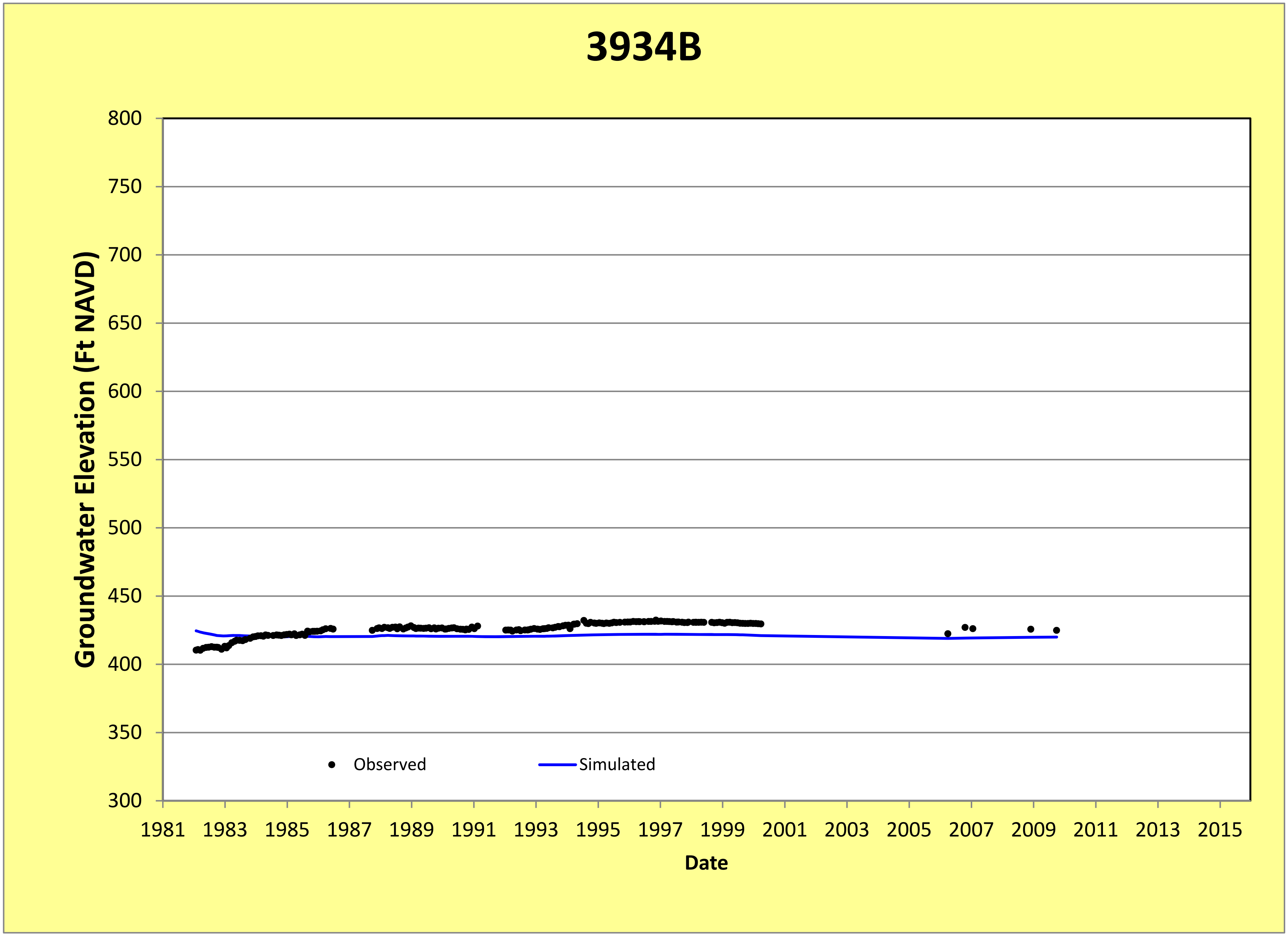
2015
Date


3934B
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
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350
300
Observed
Simulated
1981
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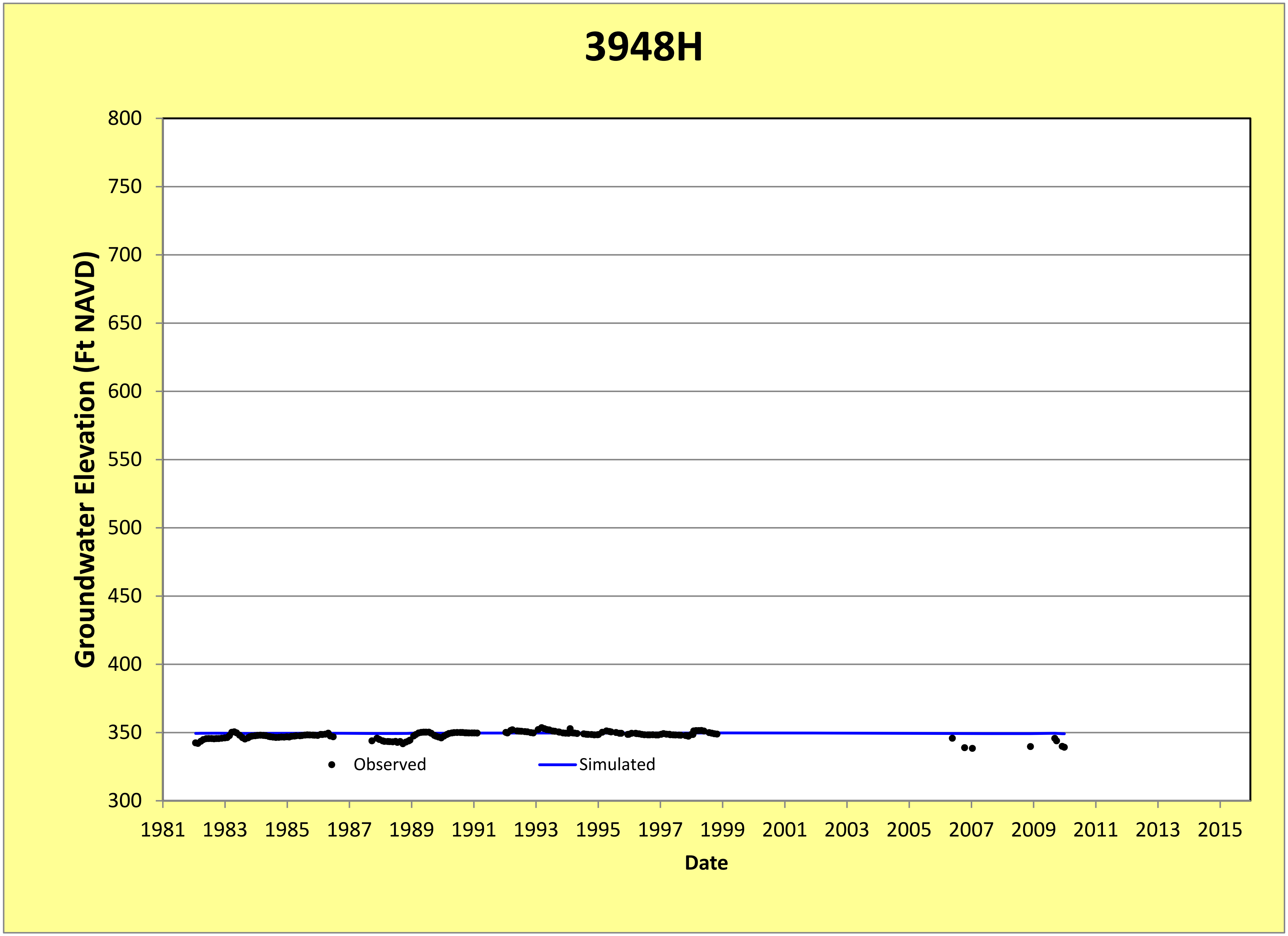
Date



3948H
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
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450
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350
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1981
1983
1985
1987
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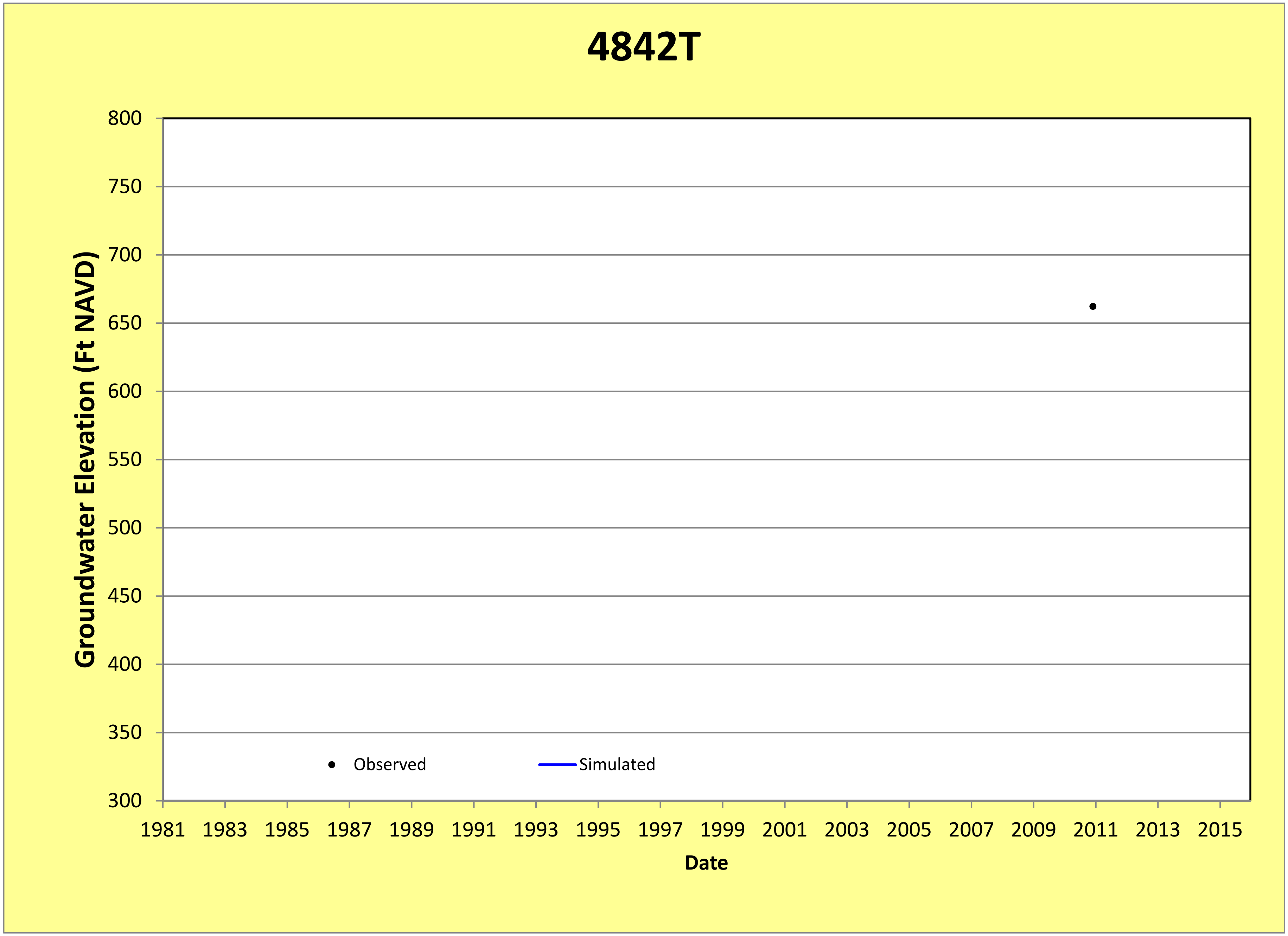
2009
2011
2013
2015
Date
Observed
Simulated


4842T
Groundwater Elevation (Ft NAVD)
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750
700
650
600
550
500
450
400
350
300
Observed
Simulated
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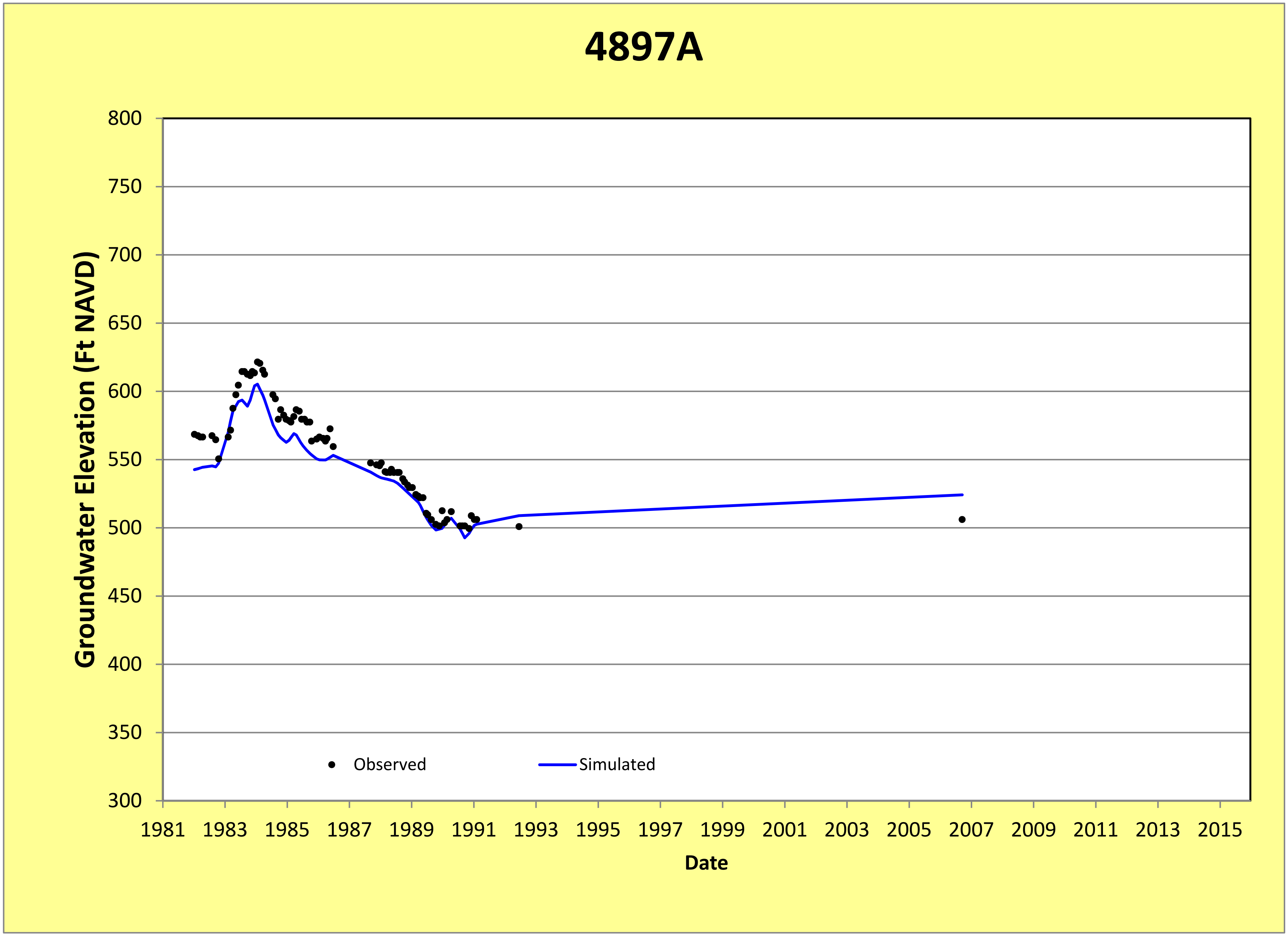
2011
2013
2015
Date



4897A
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
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1987
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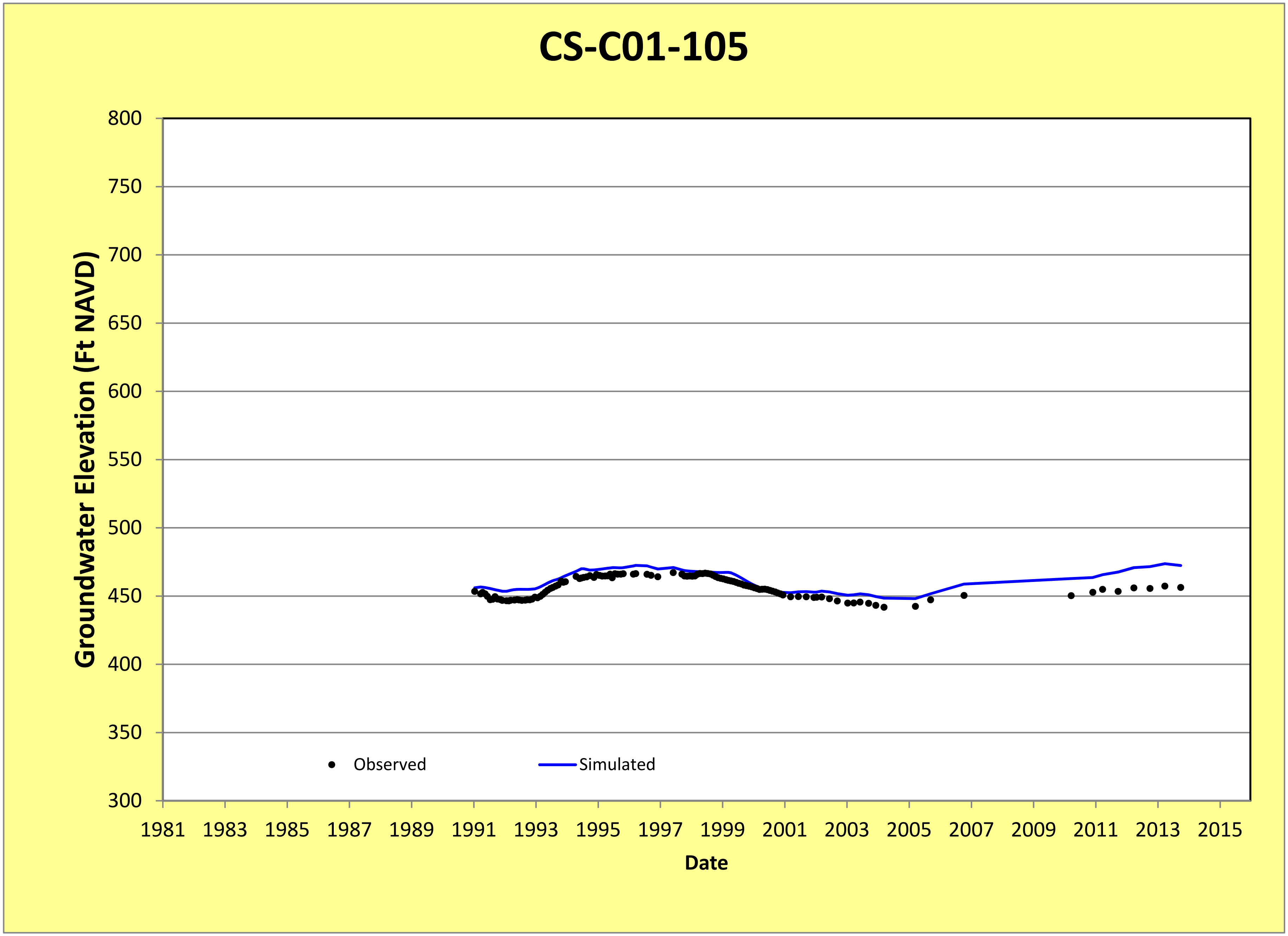
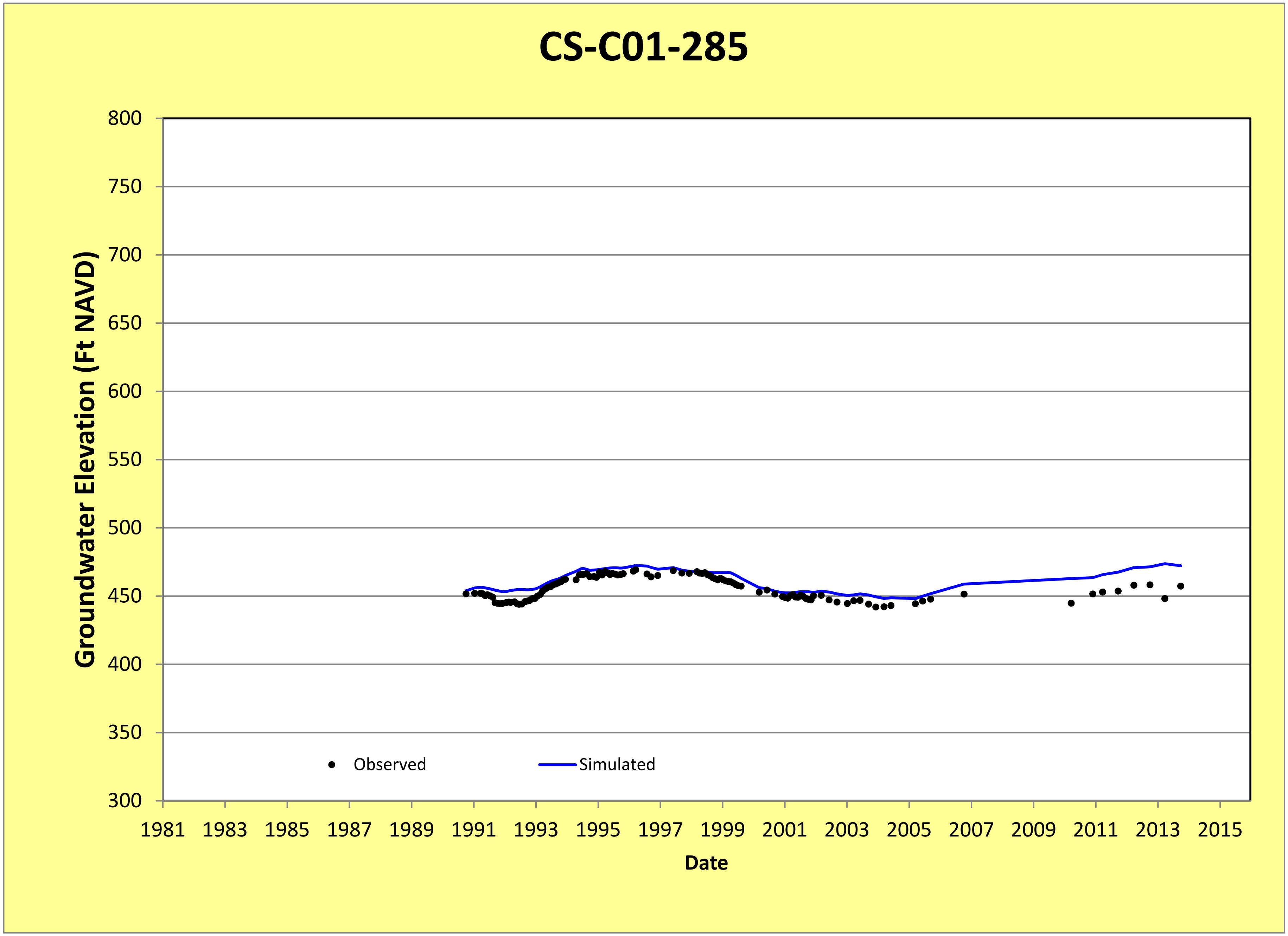
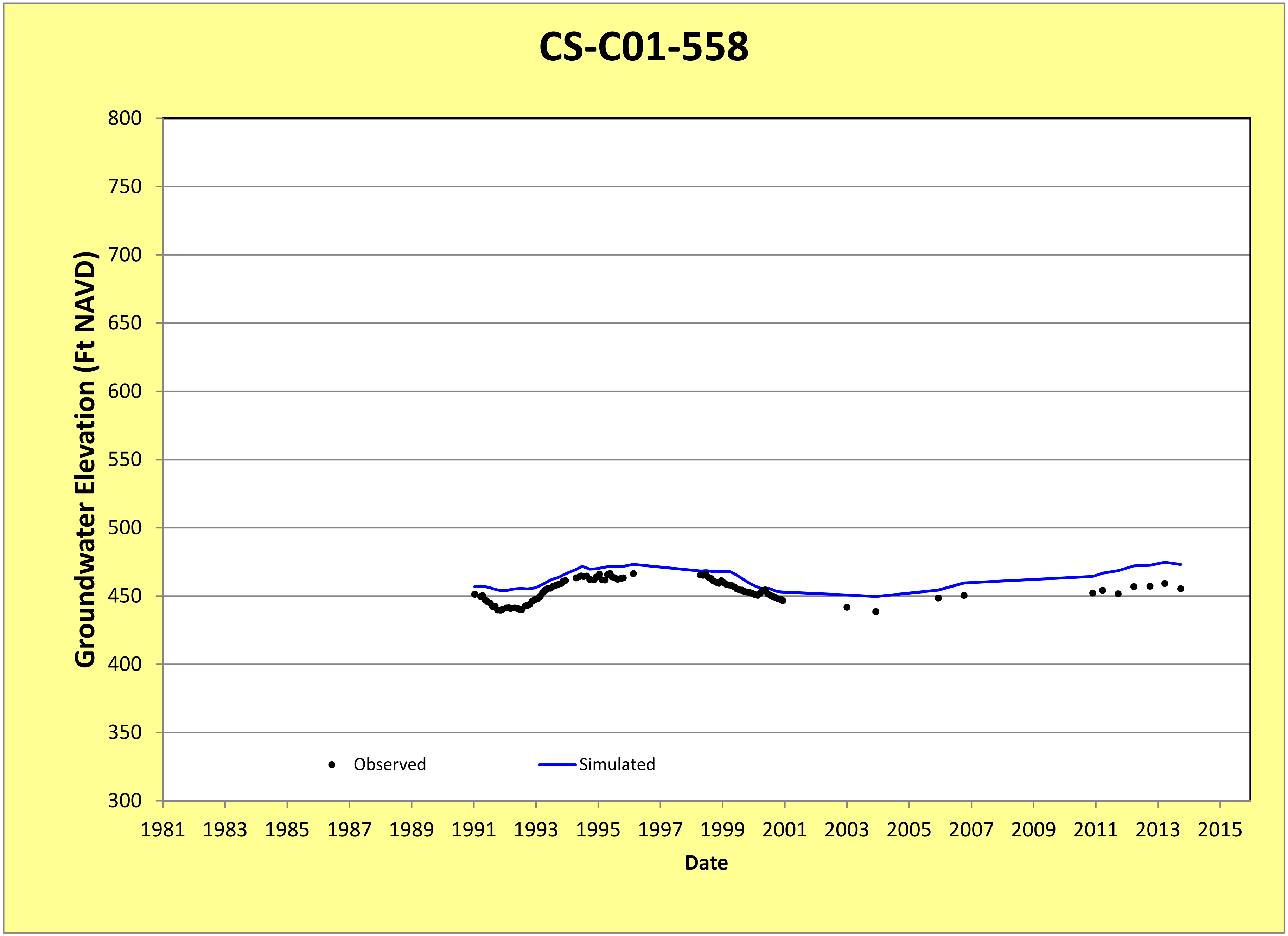
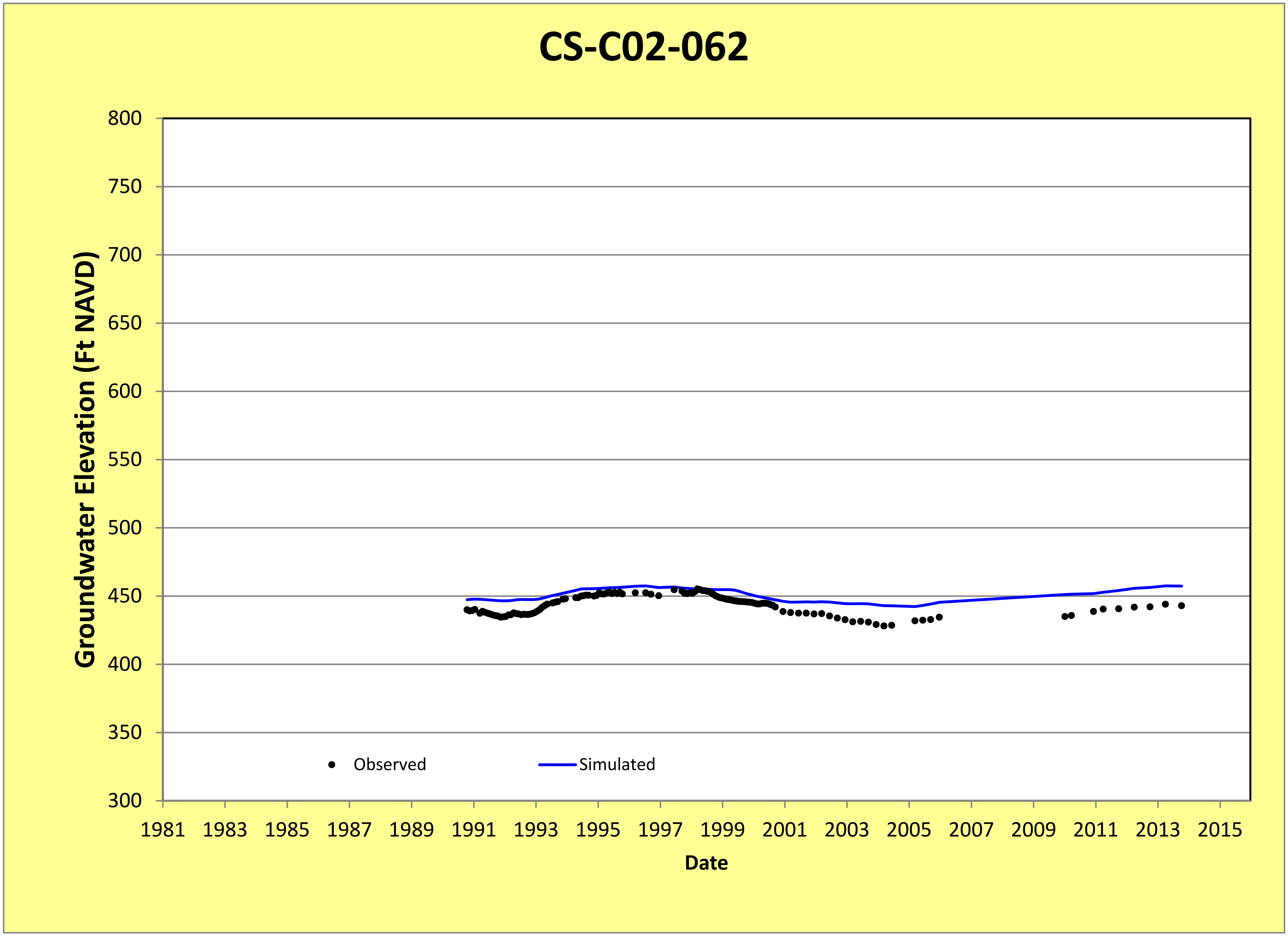
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated

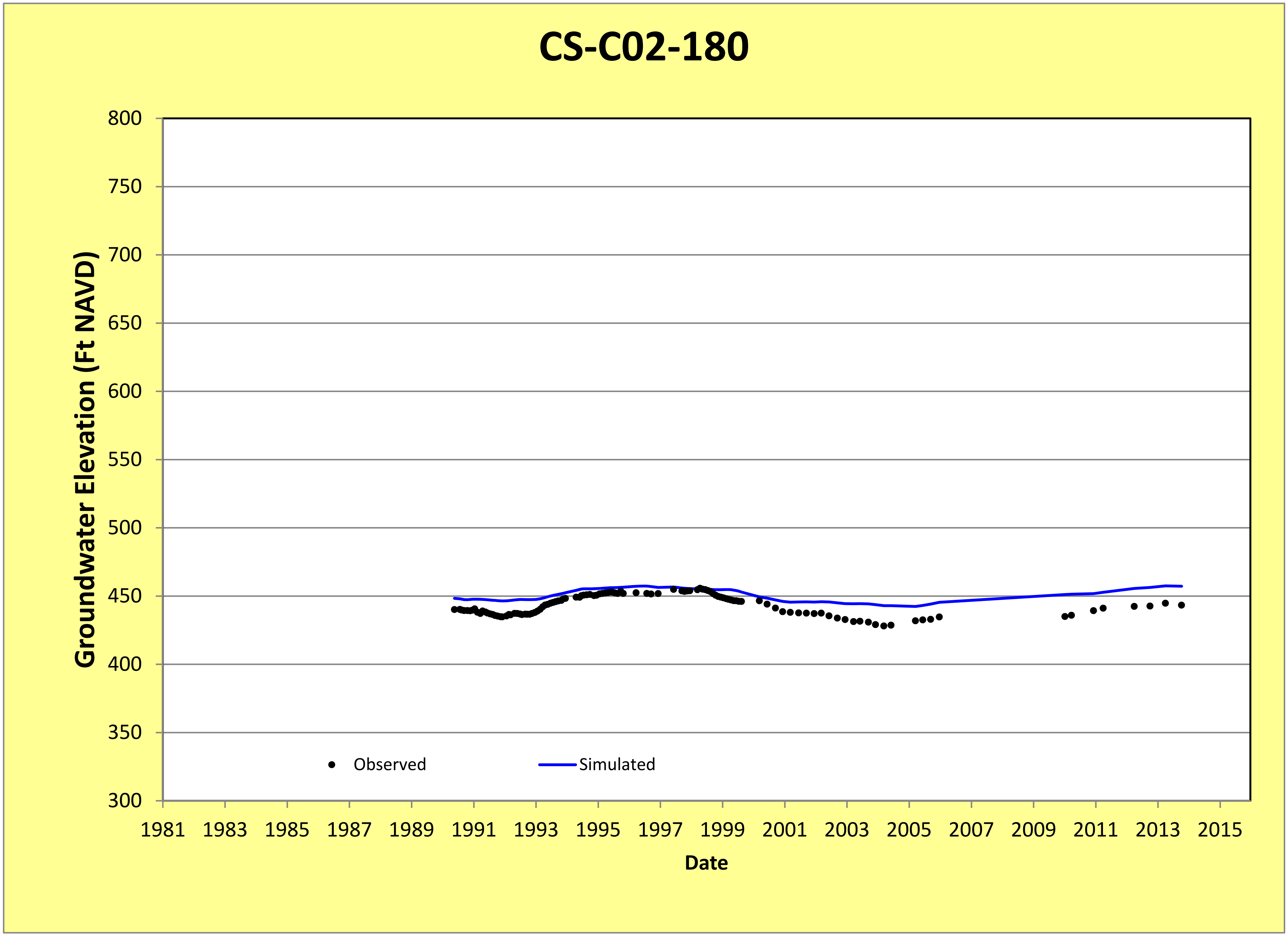


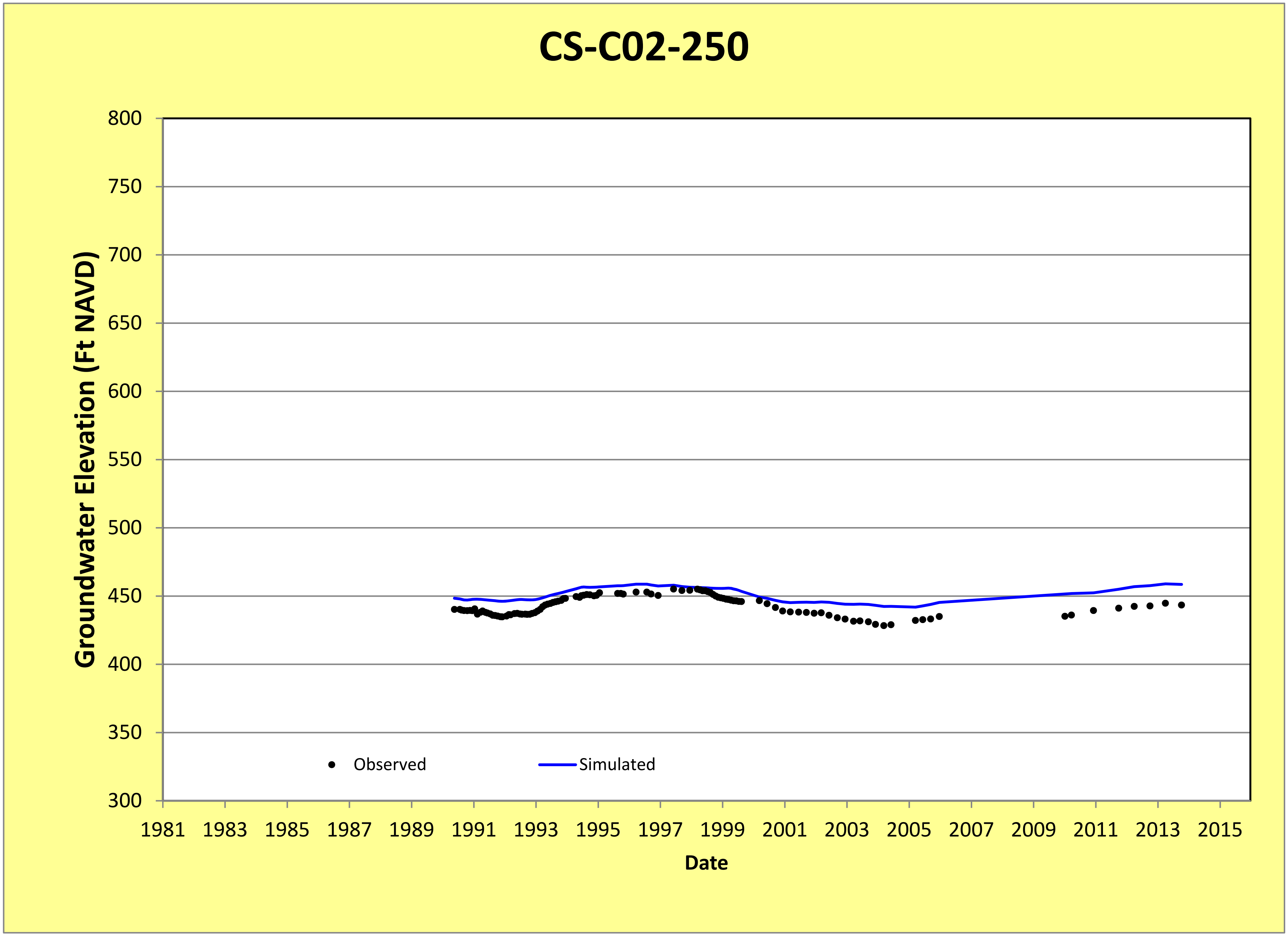
CS-C01-105
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated


CS-C01-285
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated

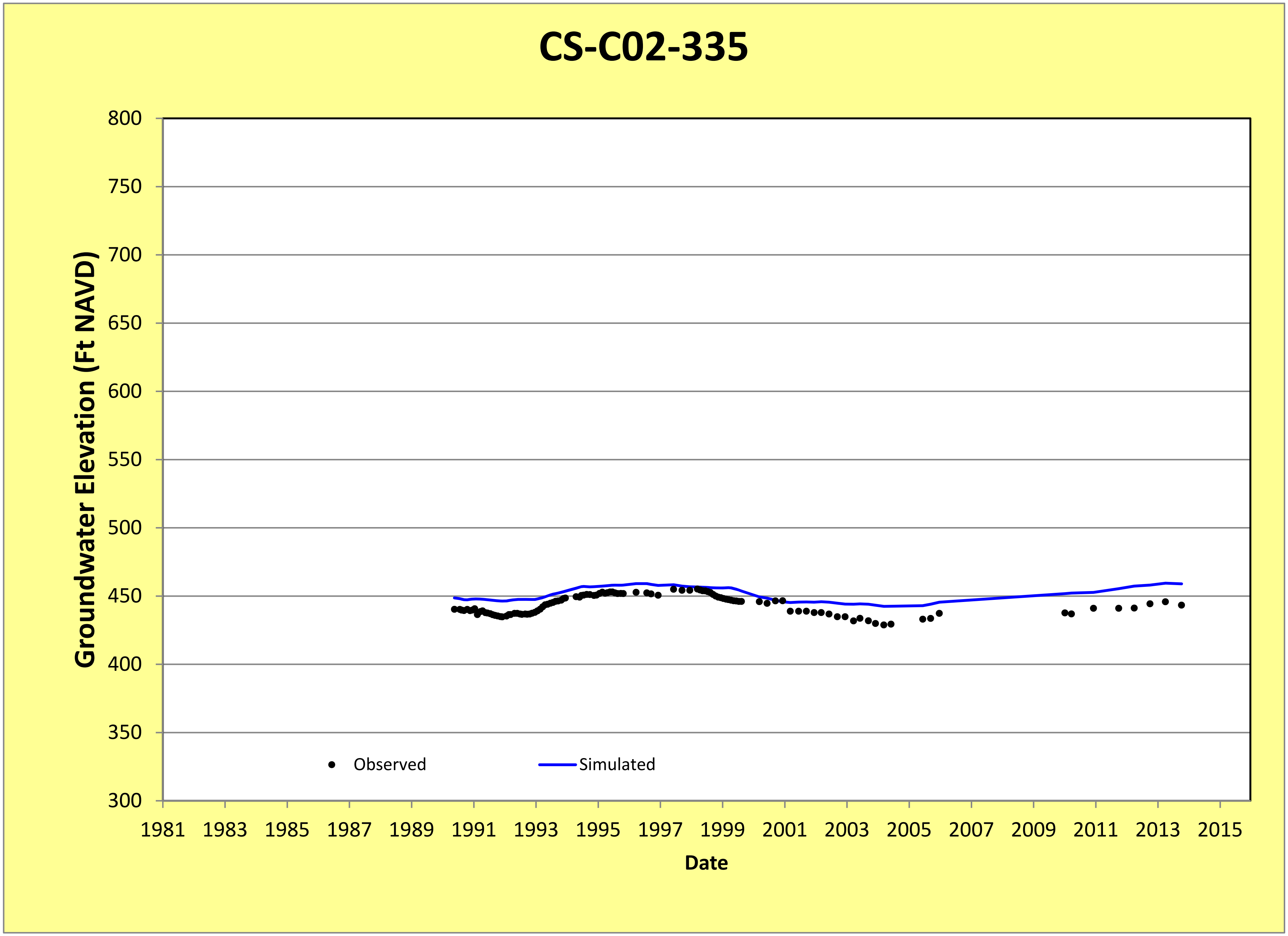

CS-C01-558
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date


CS-C02-062
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated

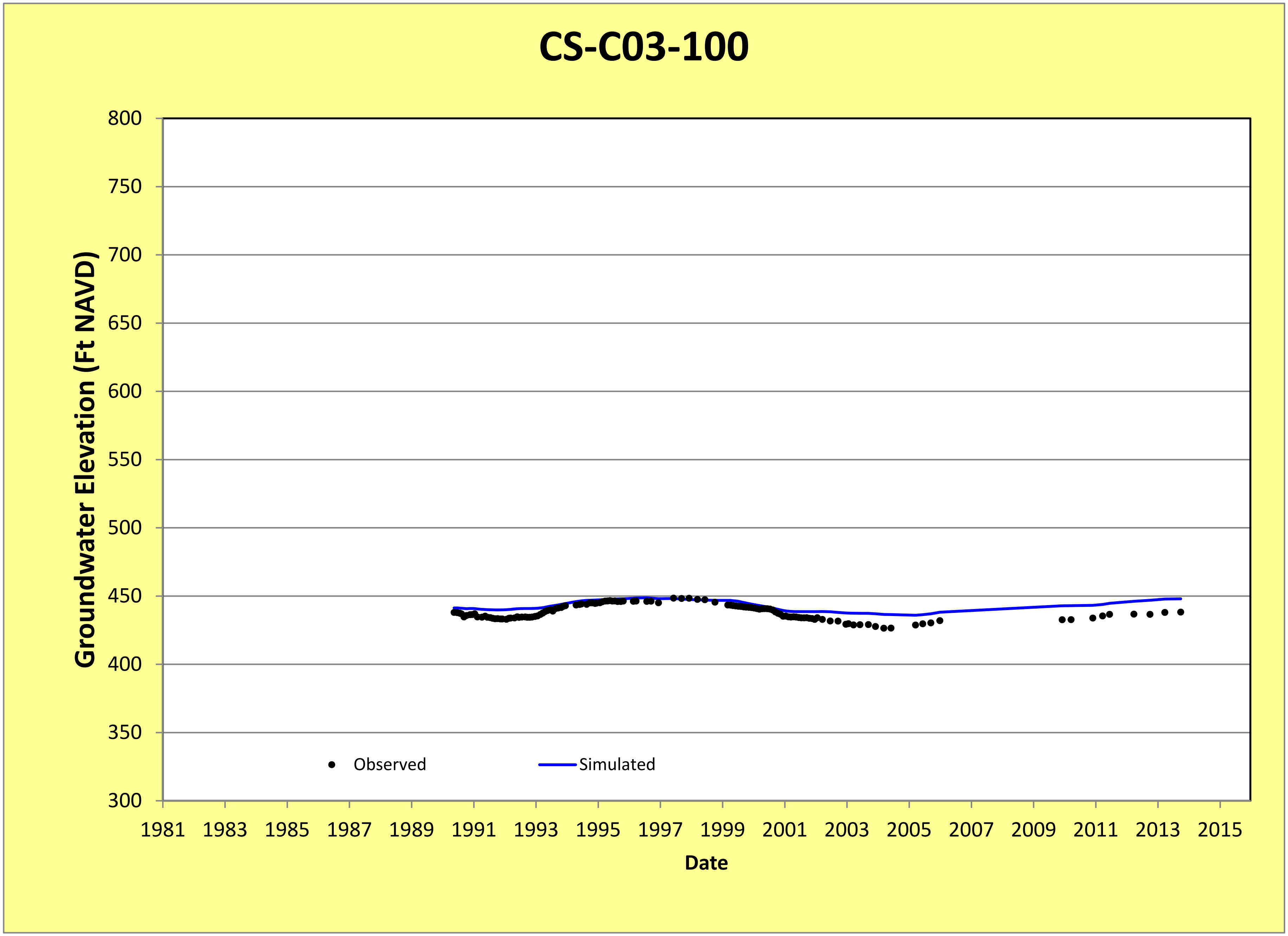

CS-C02-180
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date

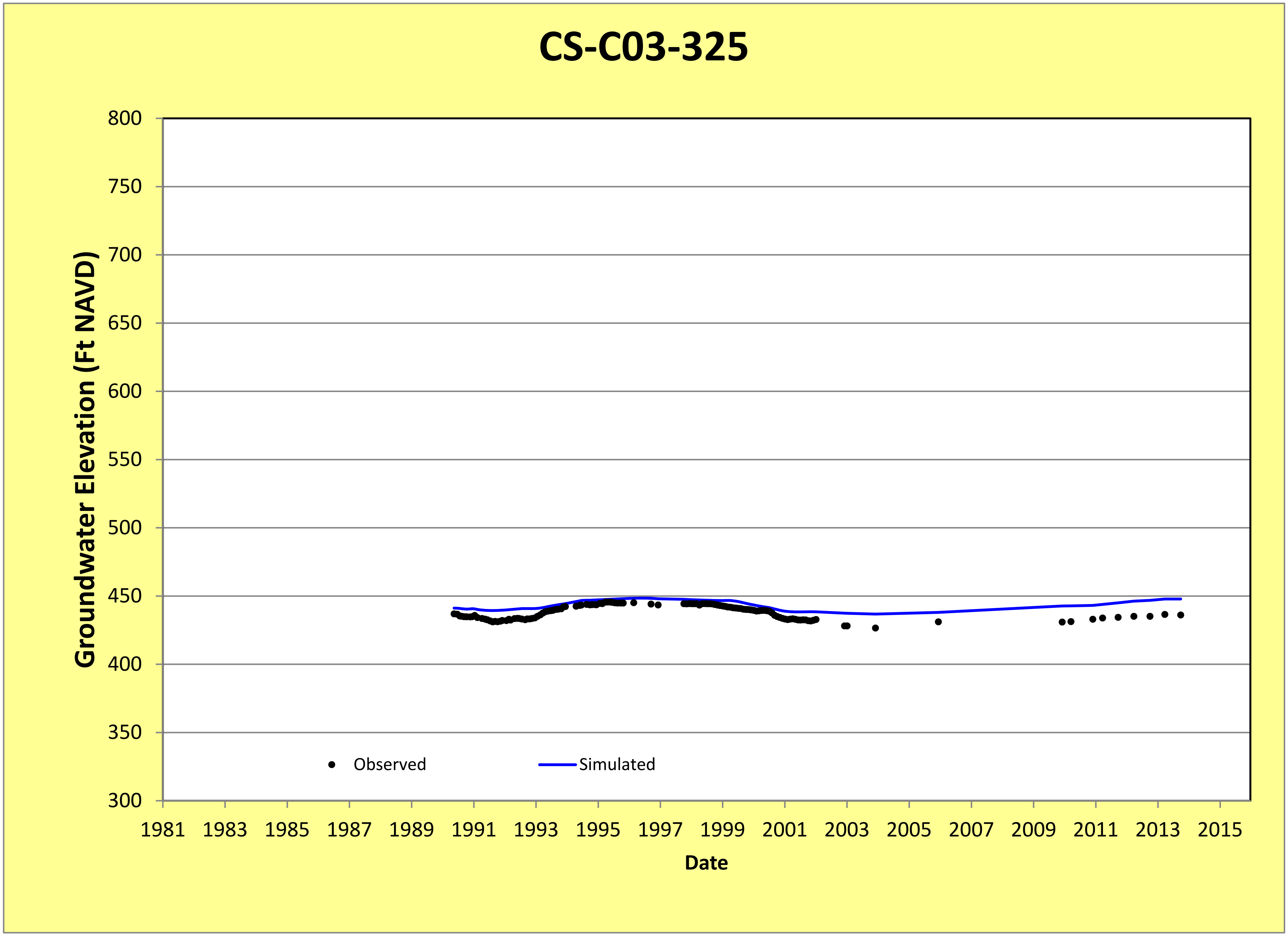


CS-C02-250
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date

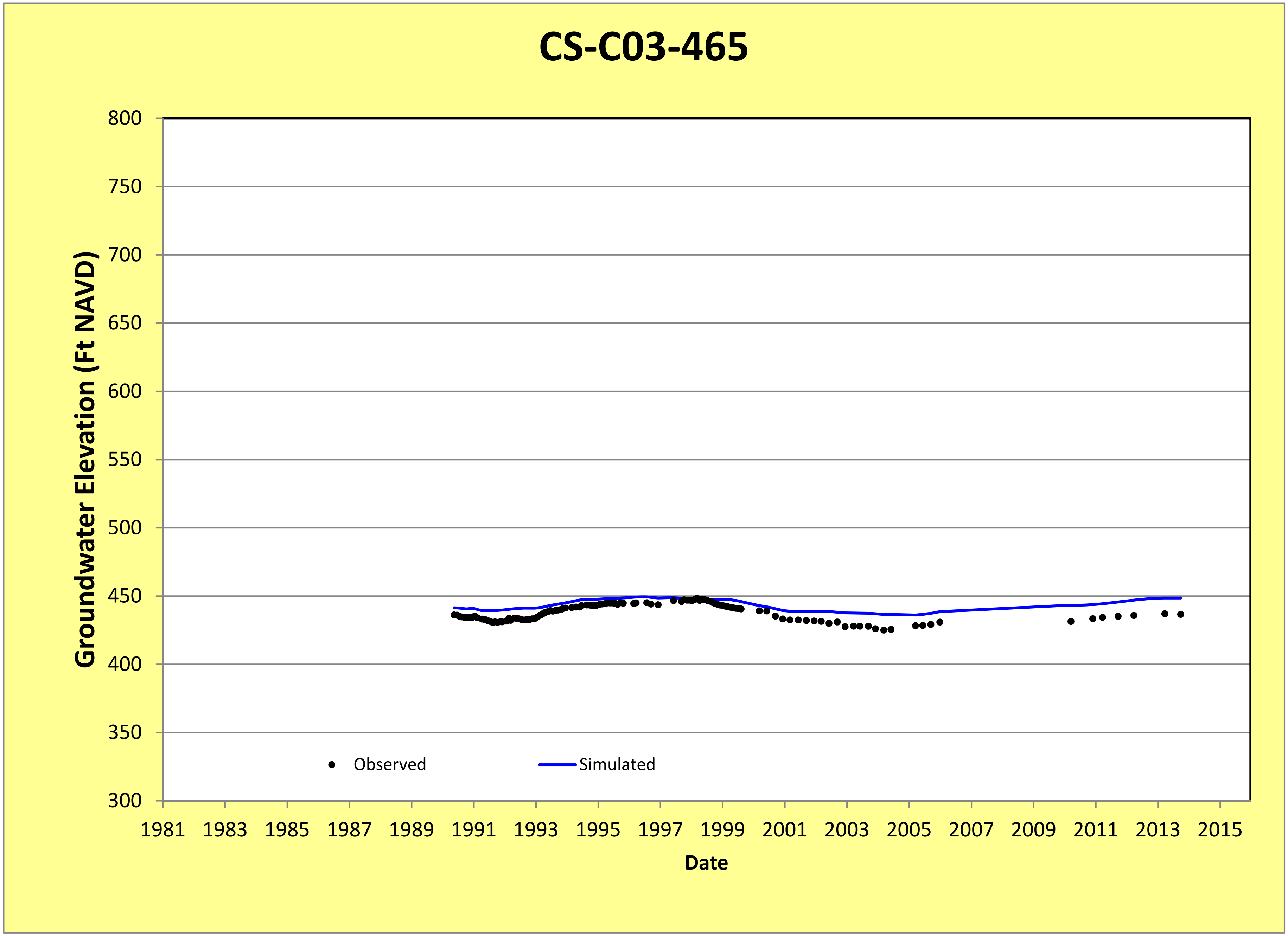


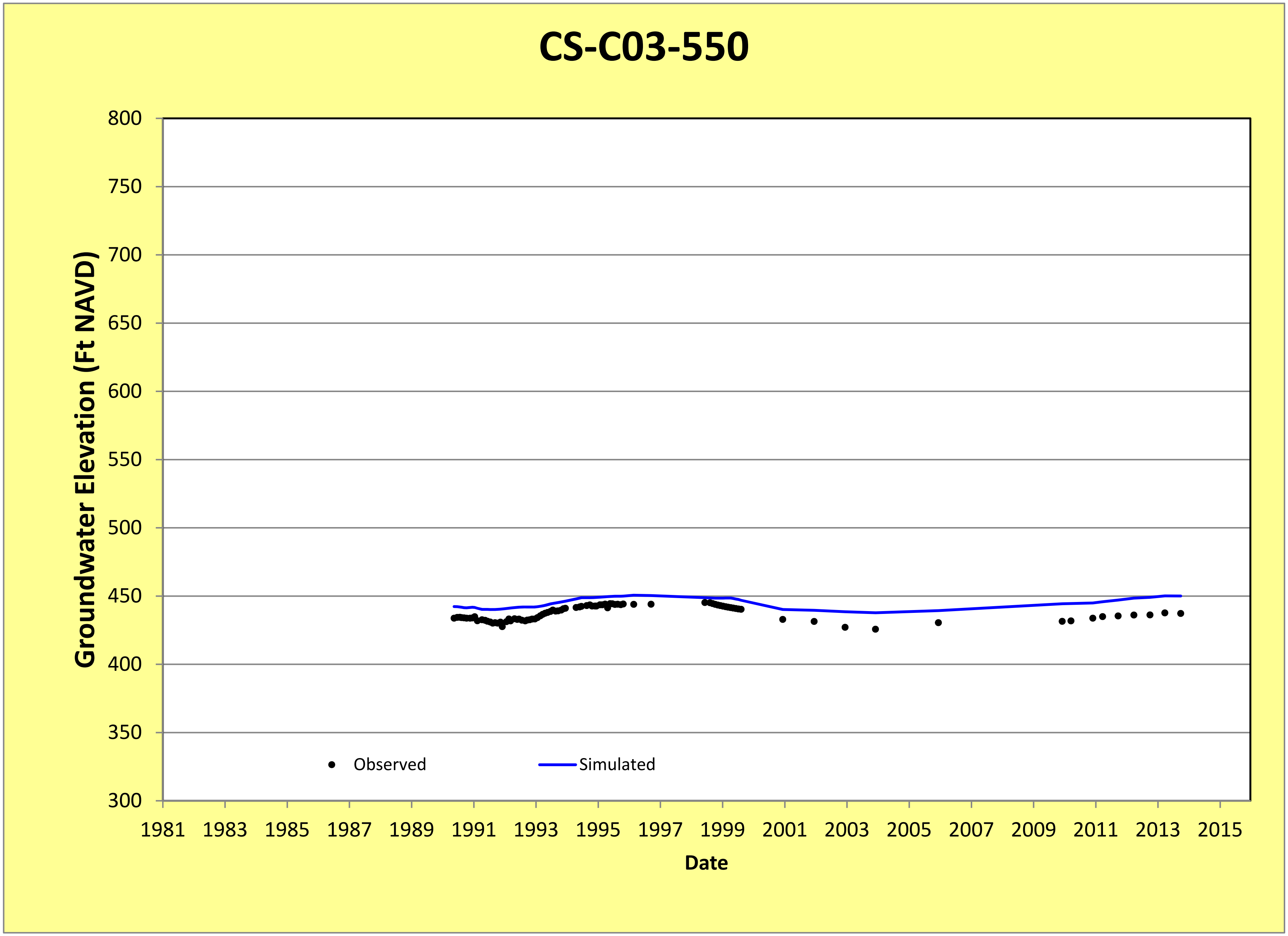
CS-C02-335
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated

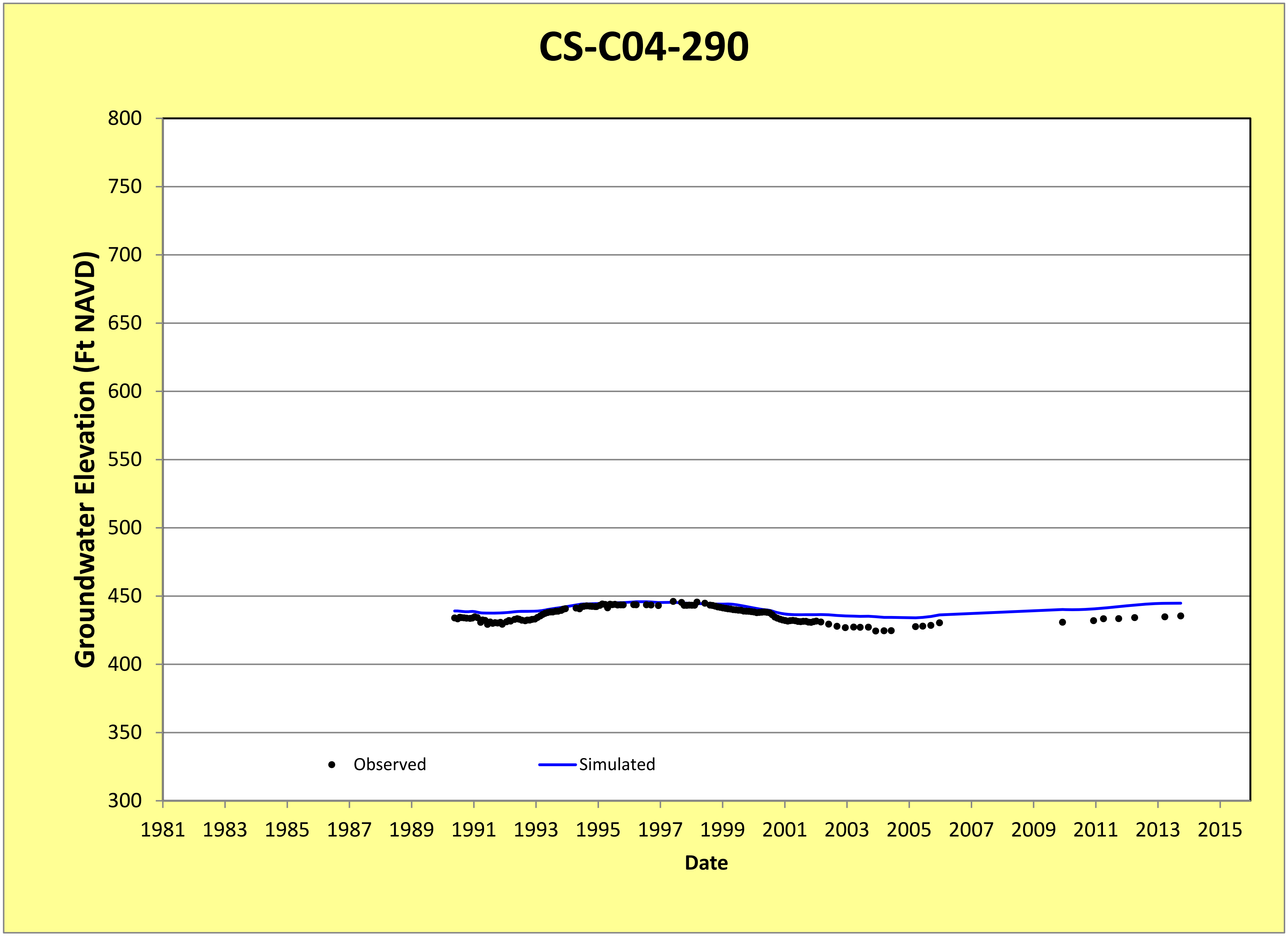

CS-C03-100
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated

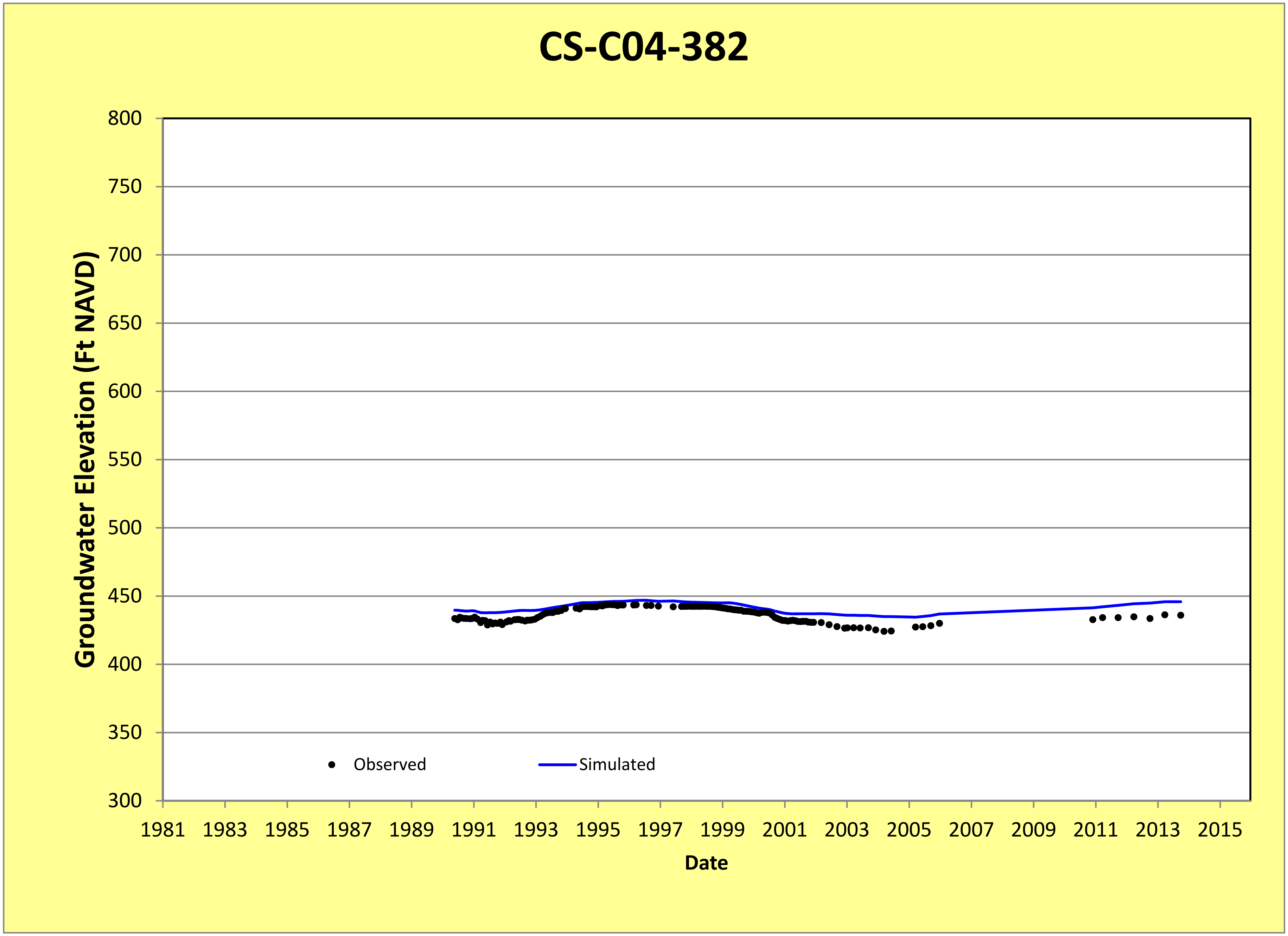


CS-C03-325
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date

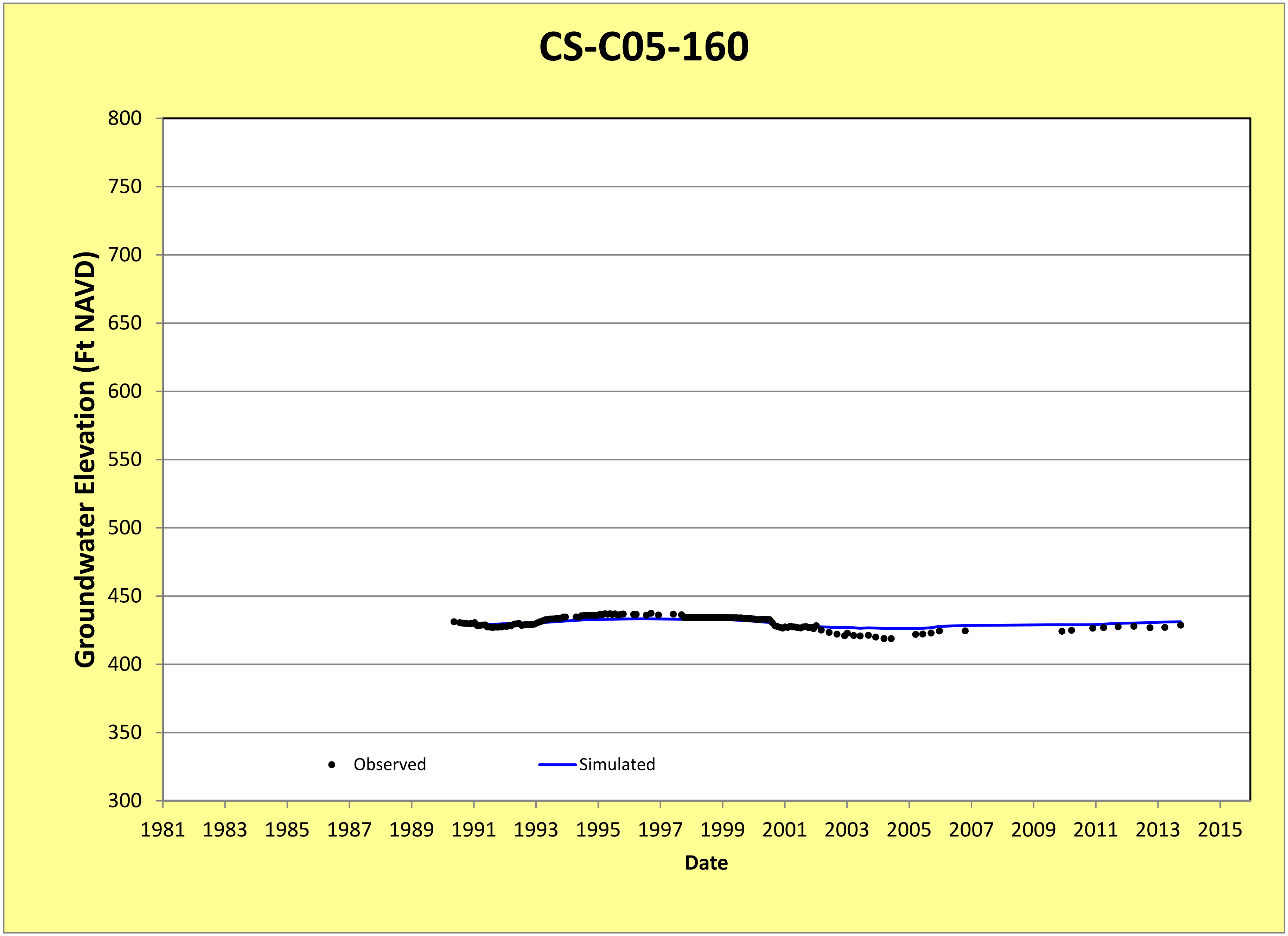

CS-C03-465
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date


CS-C03-550
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date

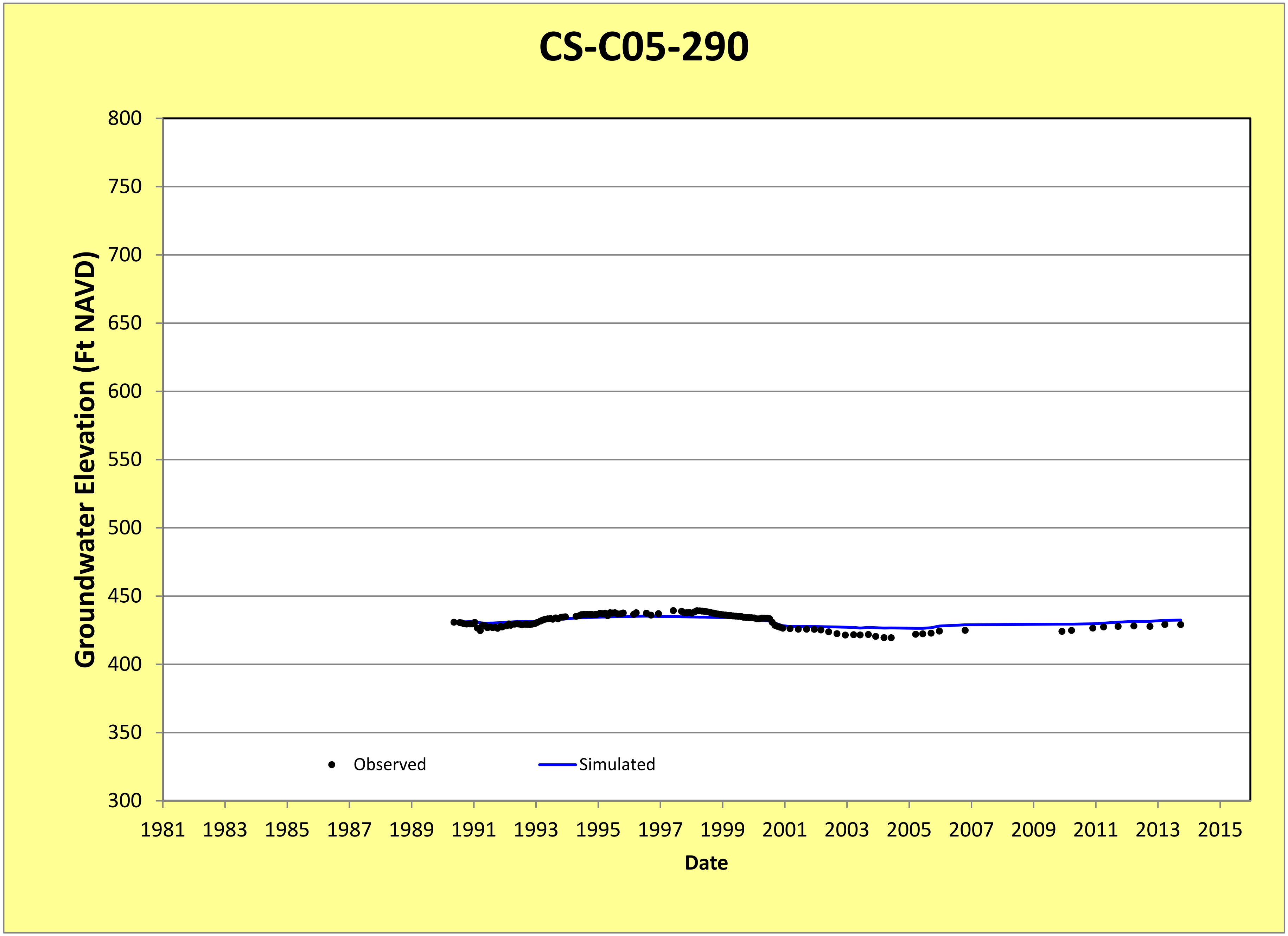

CS-C04-290
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date



CS-C04-382
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date



CS-C05-160
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date



CS-C05-290
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
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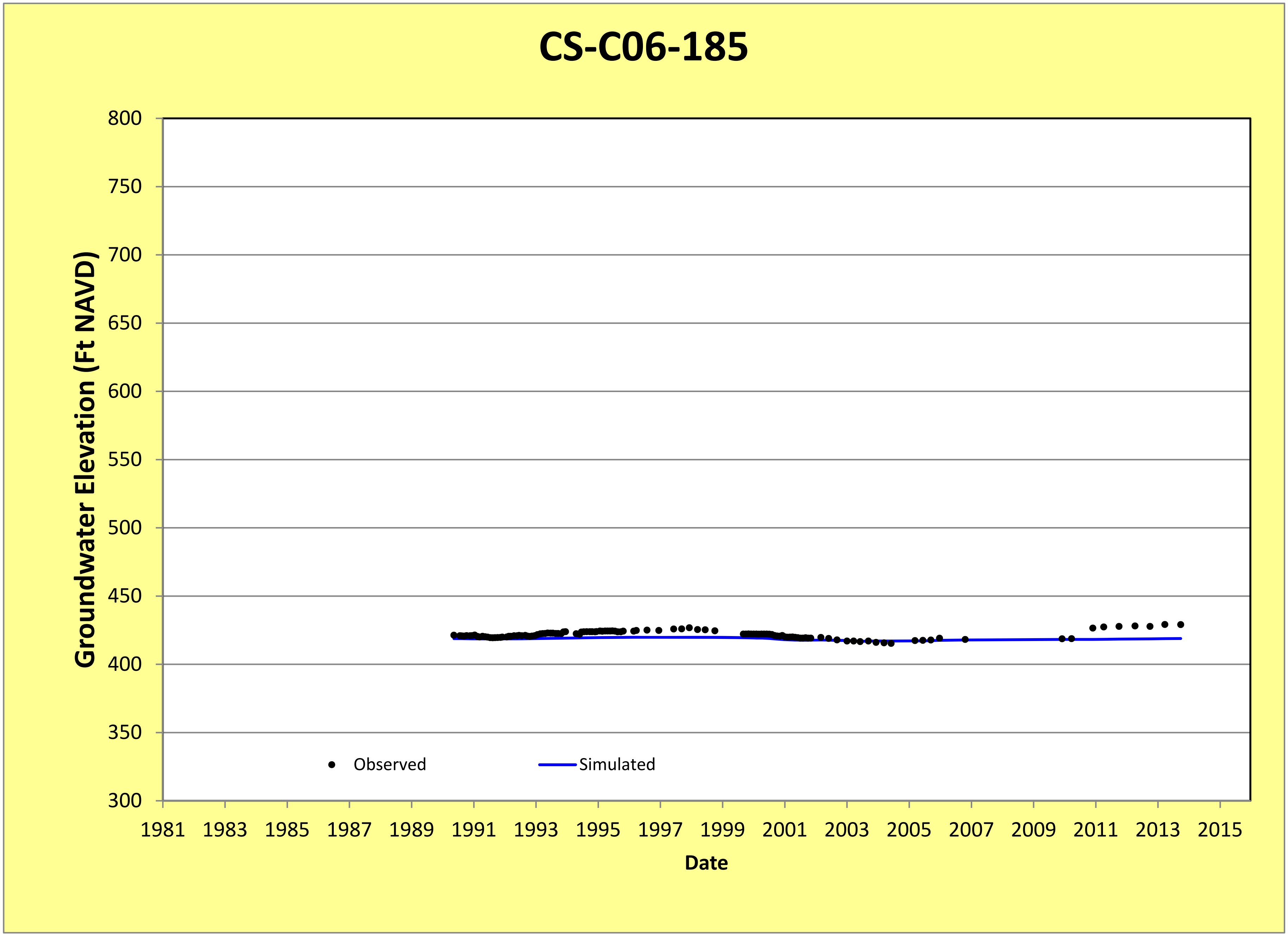
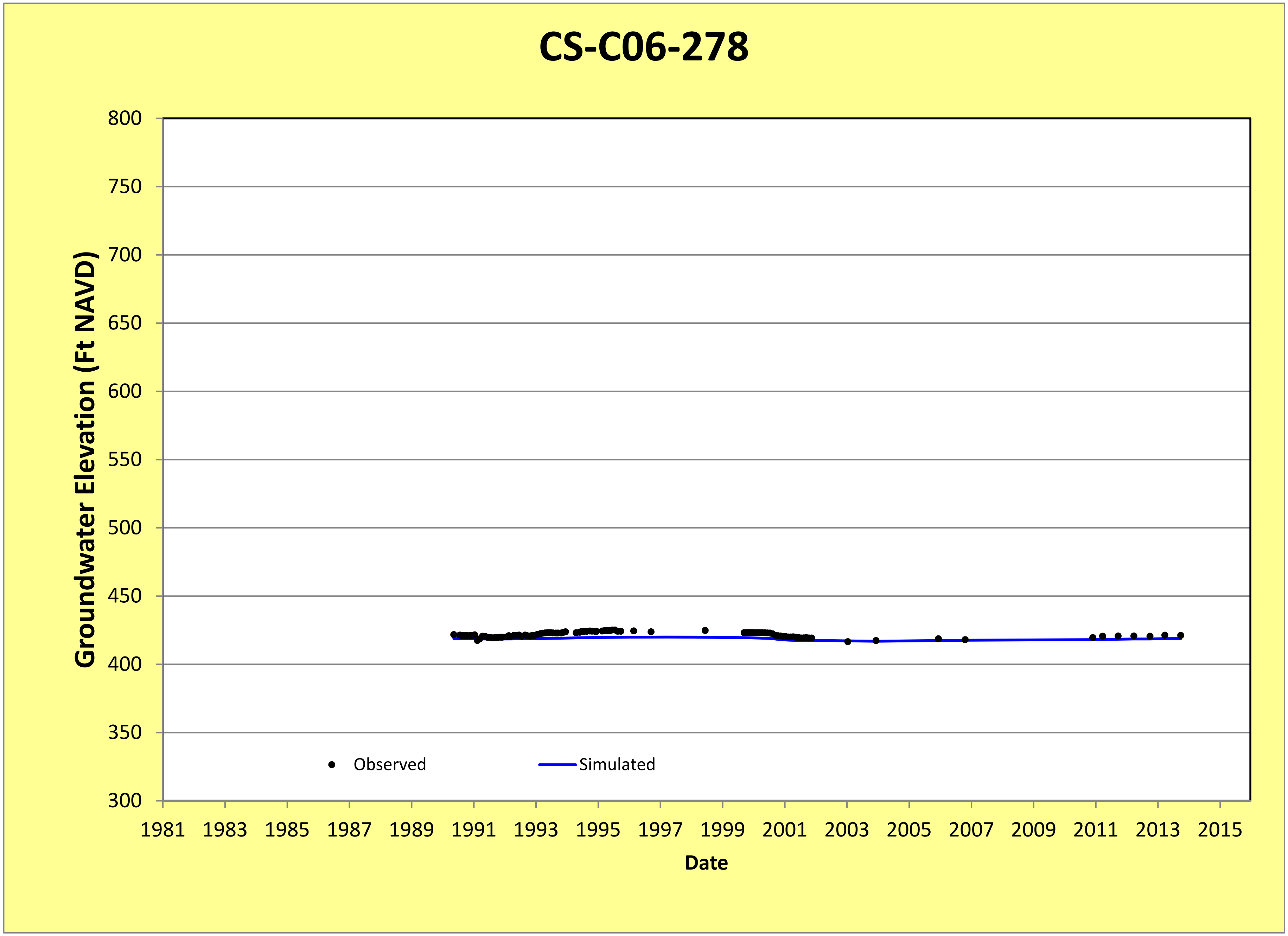
2003
2005
2007
2009
2011
2013
2015
Date


CS-C06-185
800
750
700
650
600
550
500
450
400
350
300
Groundwater Elevation (Ft NAVD)
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date



CS-C06-278
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
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1995
1997
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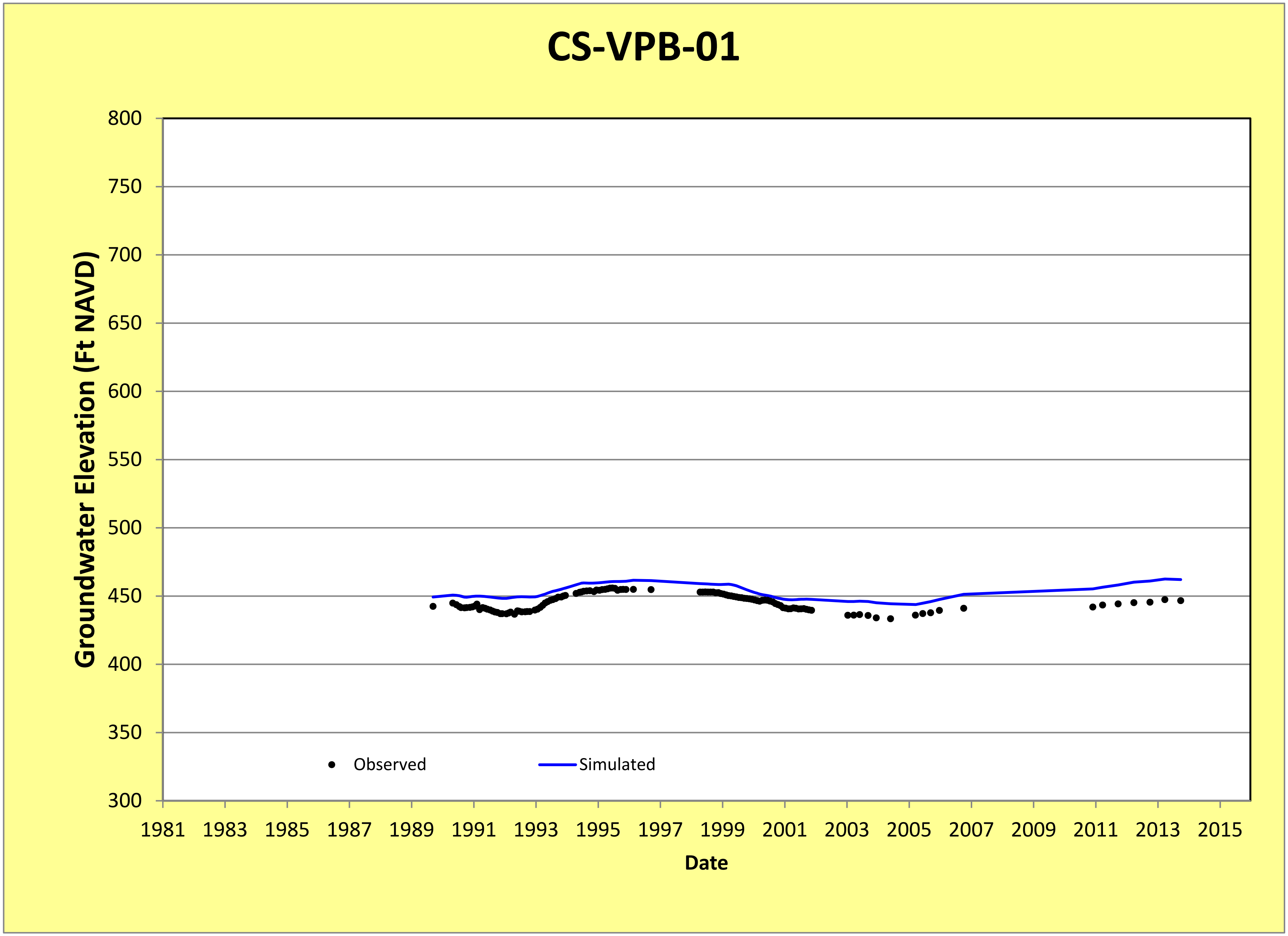
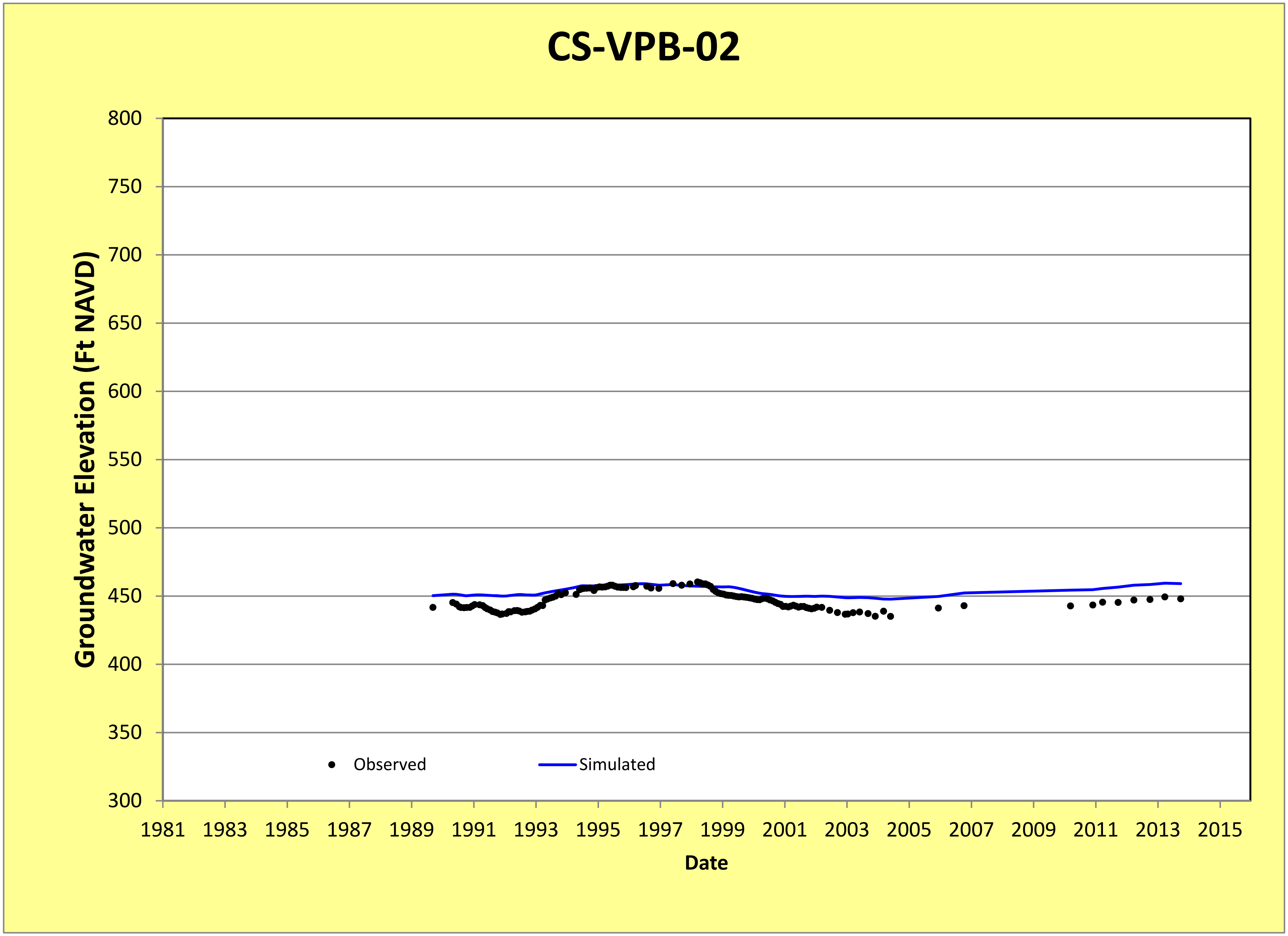
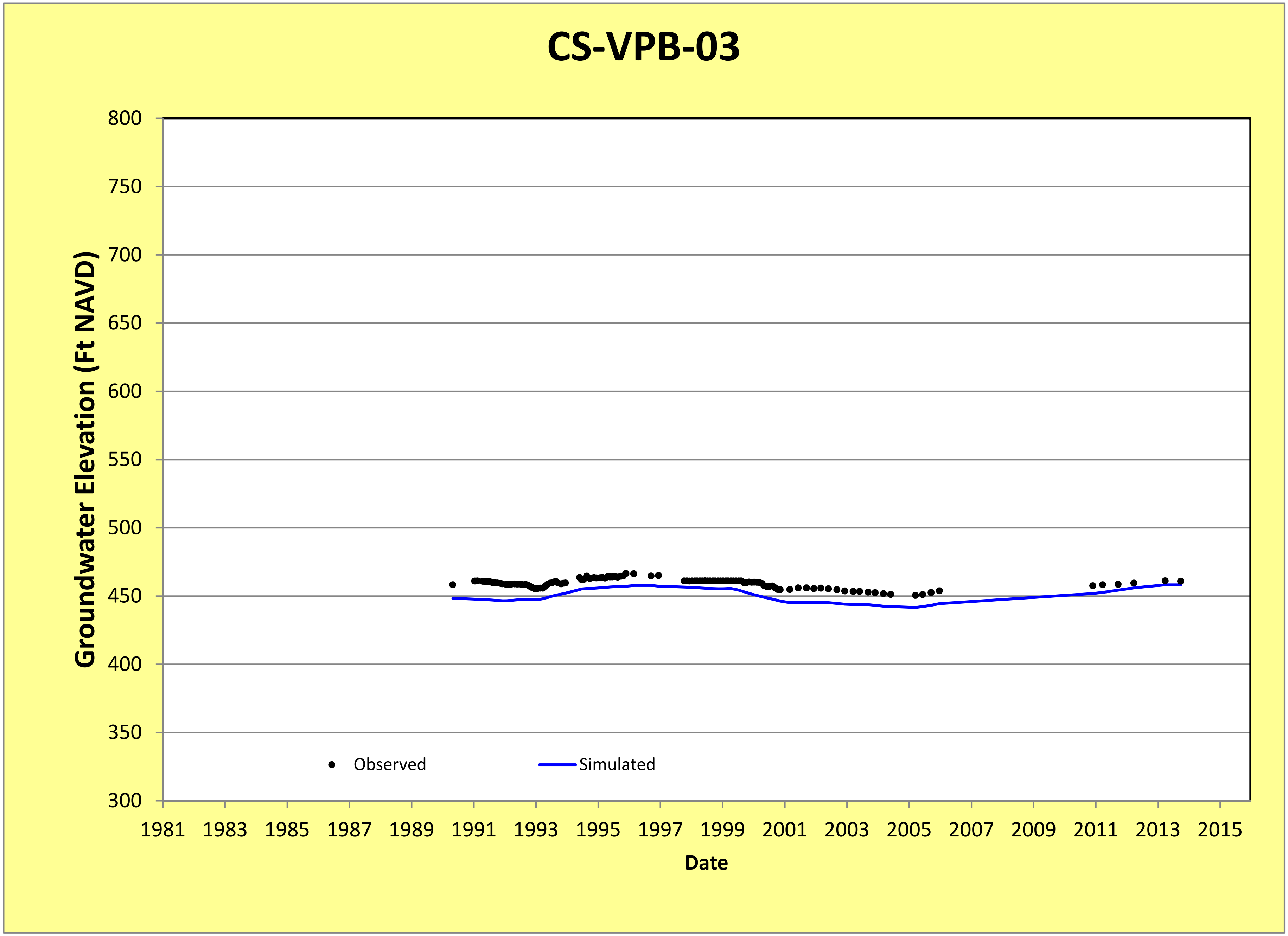
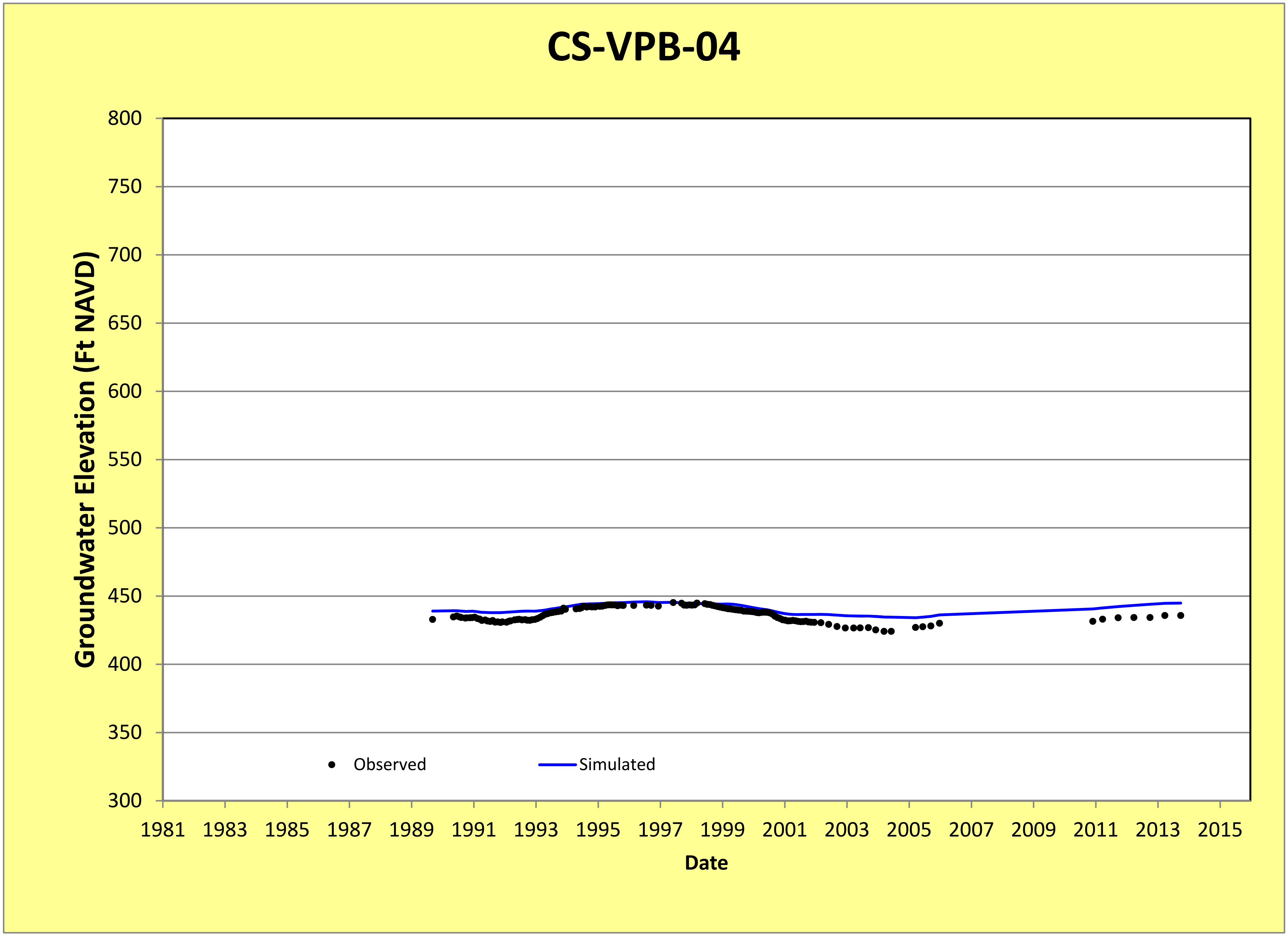
2003
2005
2007
2009
2011
2013
2015
Date


CS-VPB-01
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated

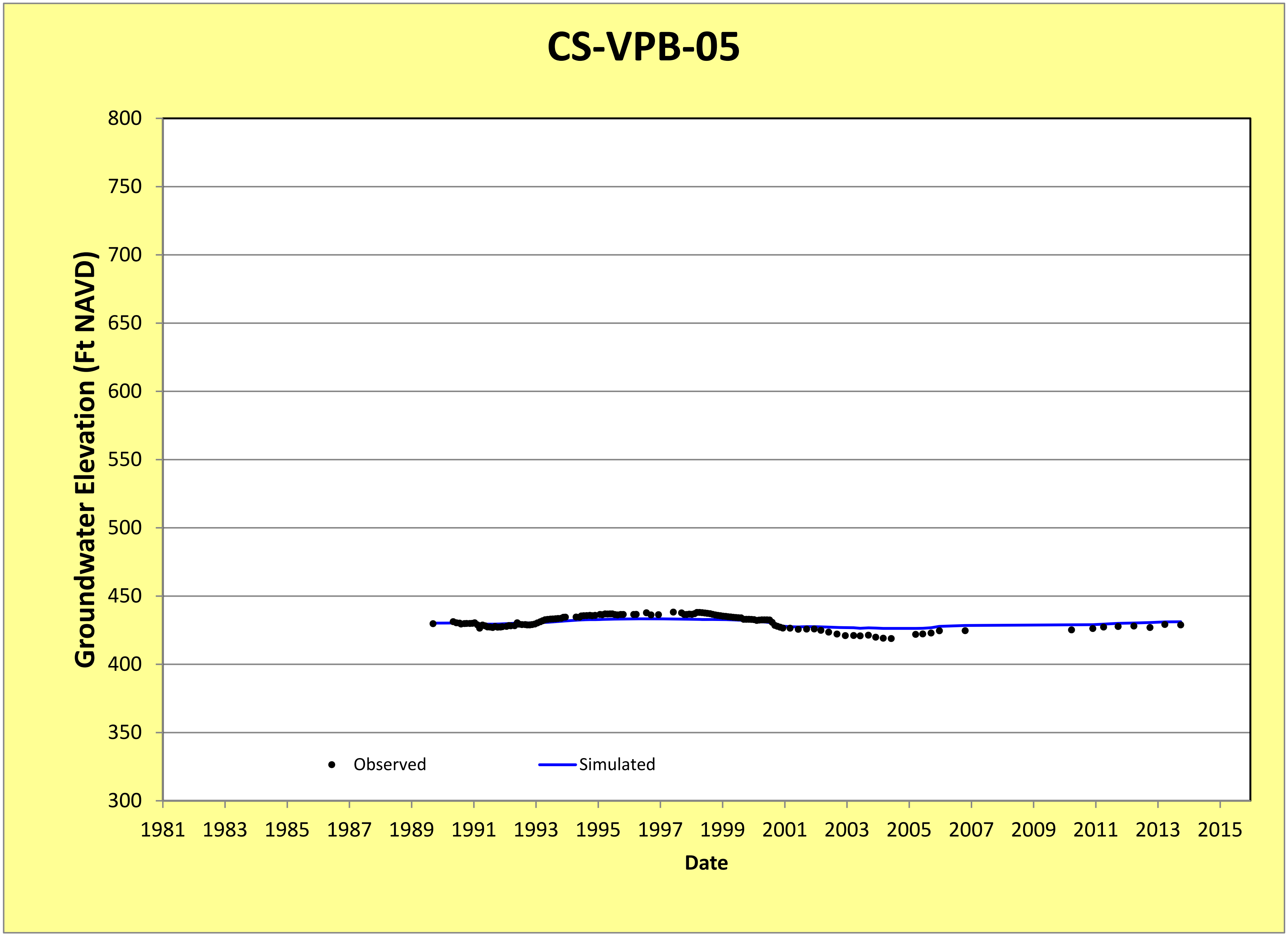

CS-VPB-02
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated



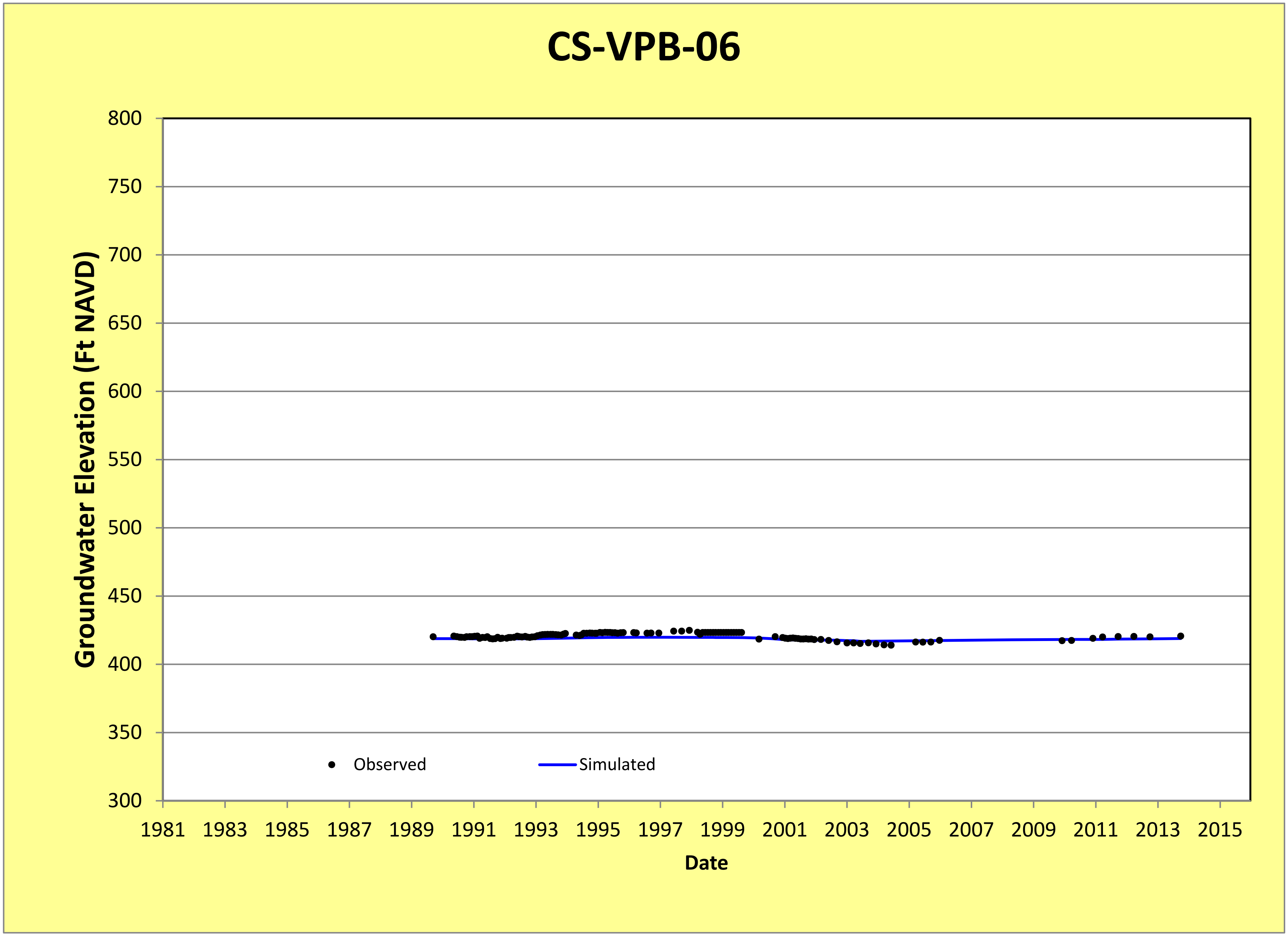
CS-VPB-03
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date



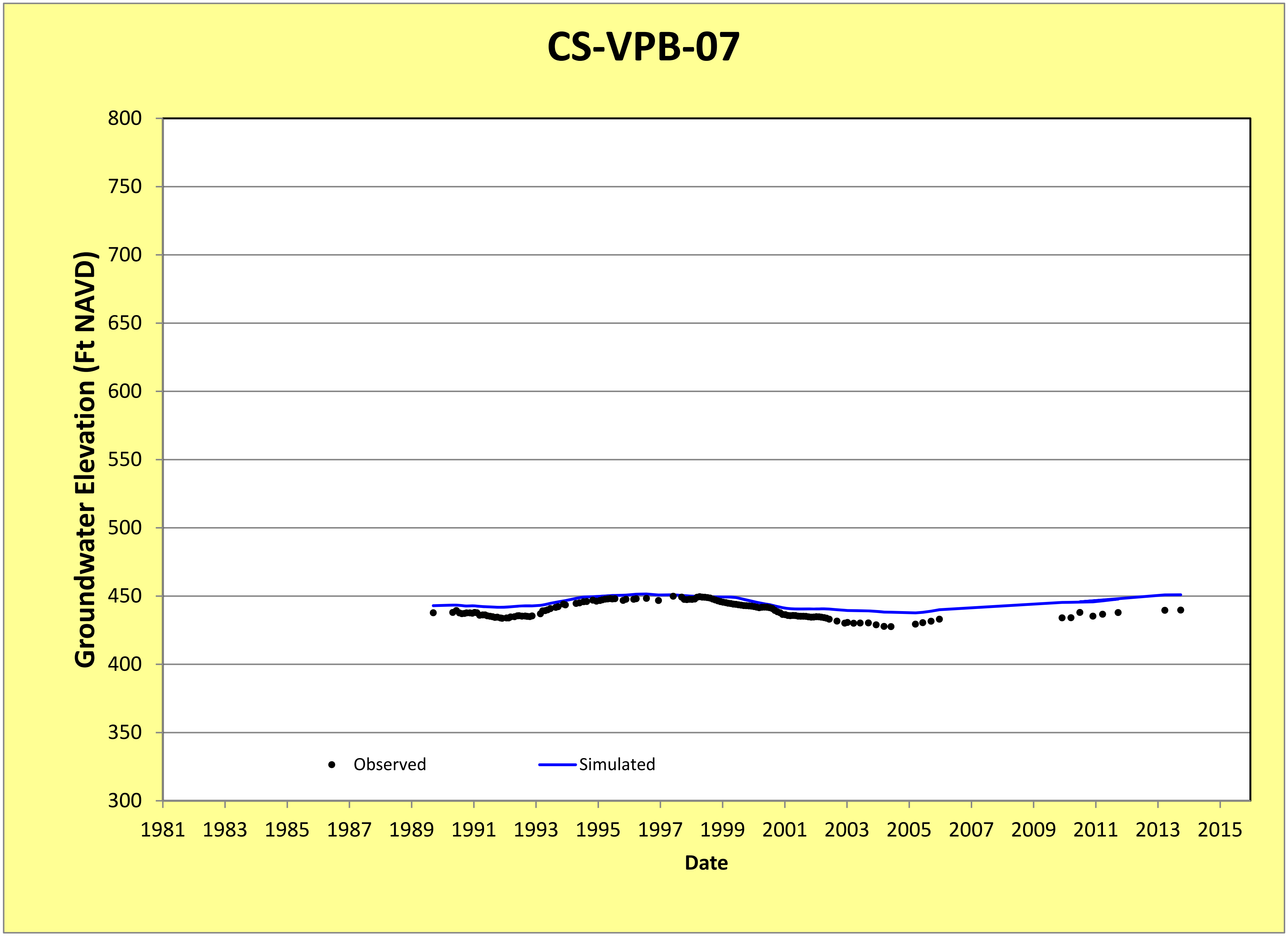
CS-VPB-04
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated



CS-VPB-05
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date



CS-VPB-06
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date


CS-VPB-07
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
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1987
1989
1991
1993
1995
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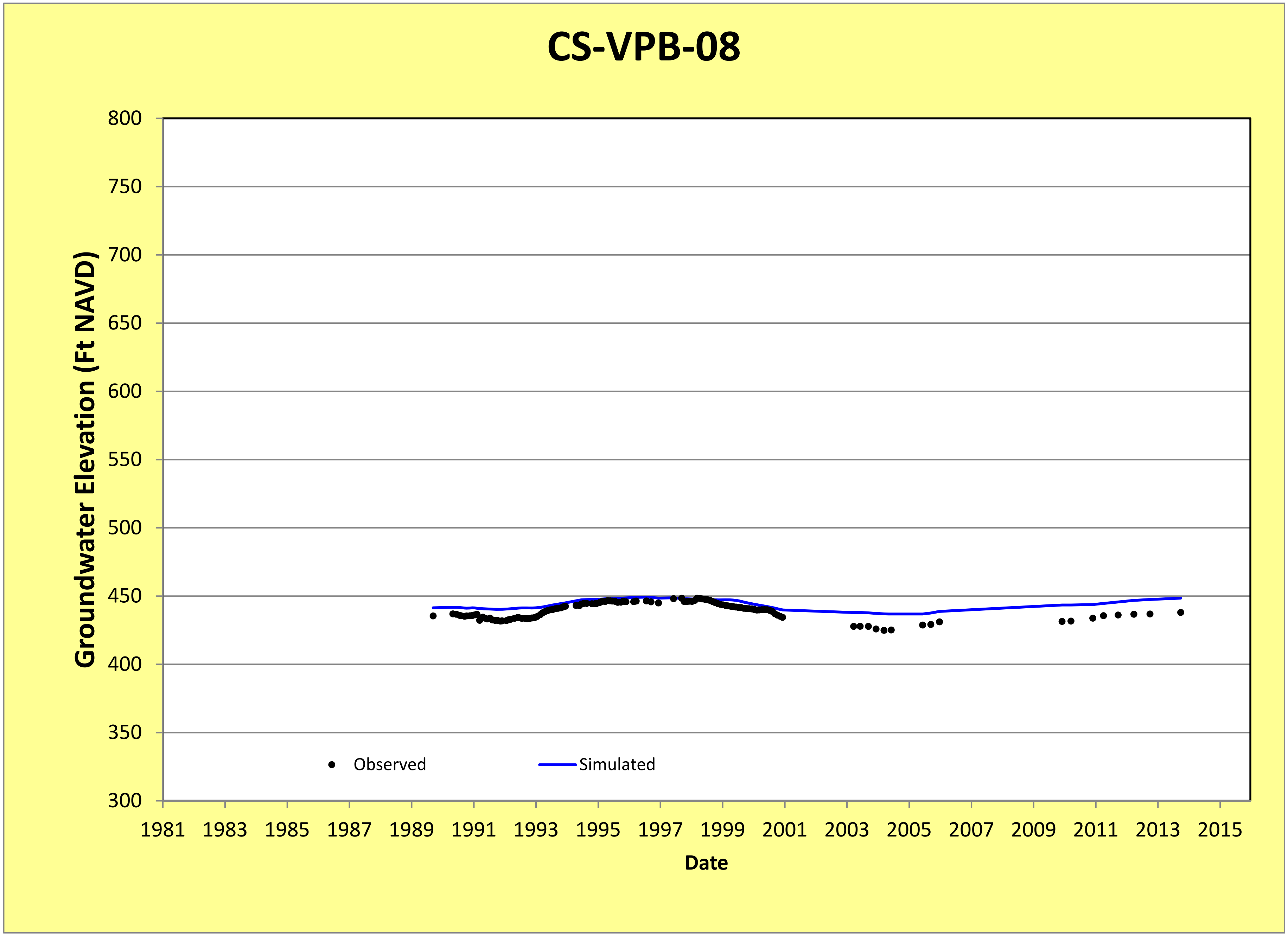
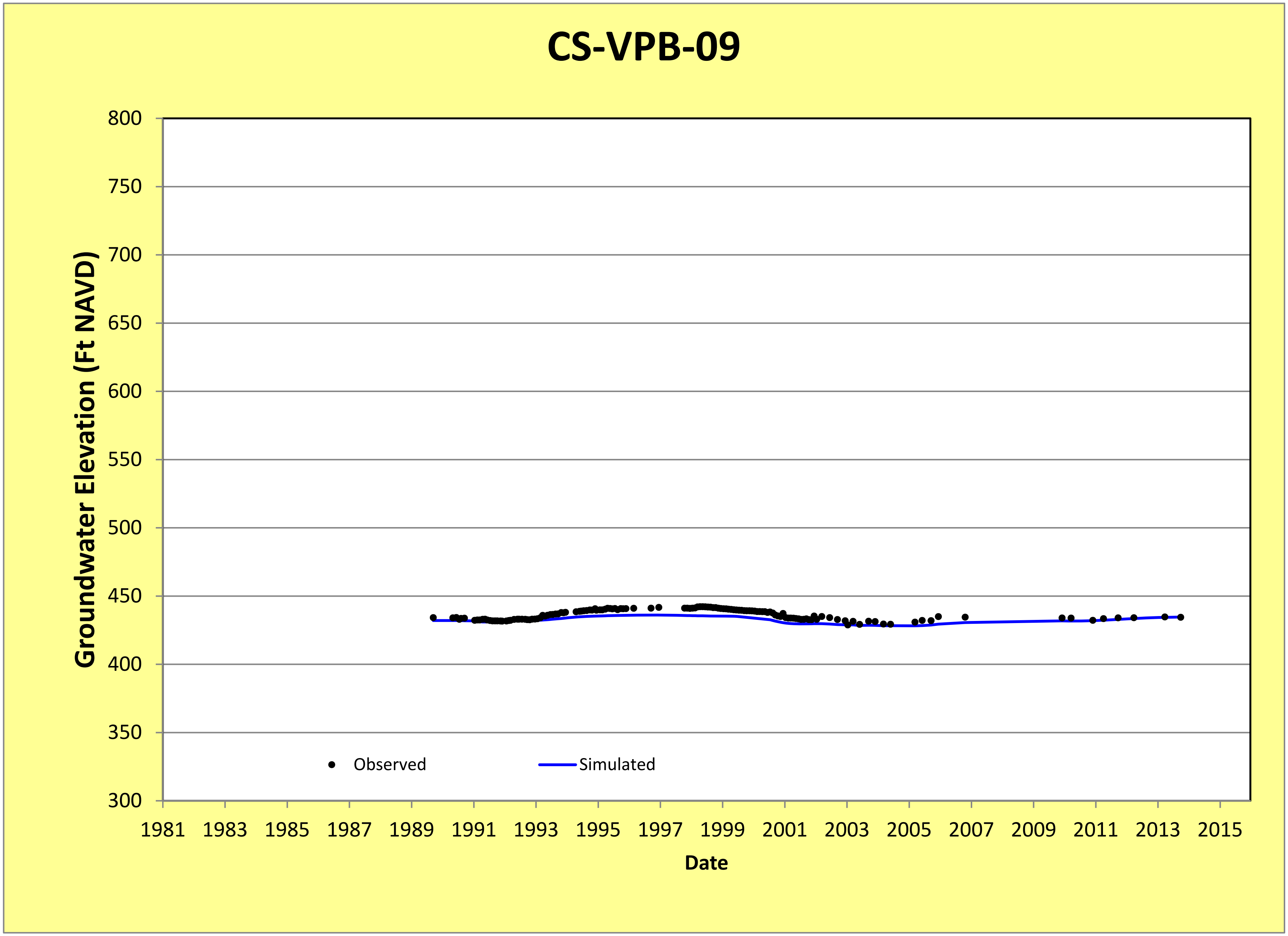
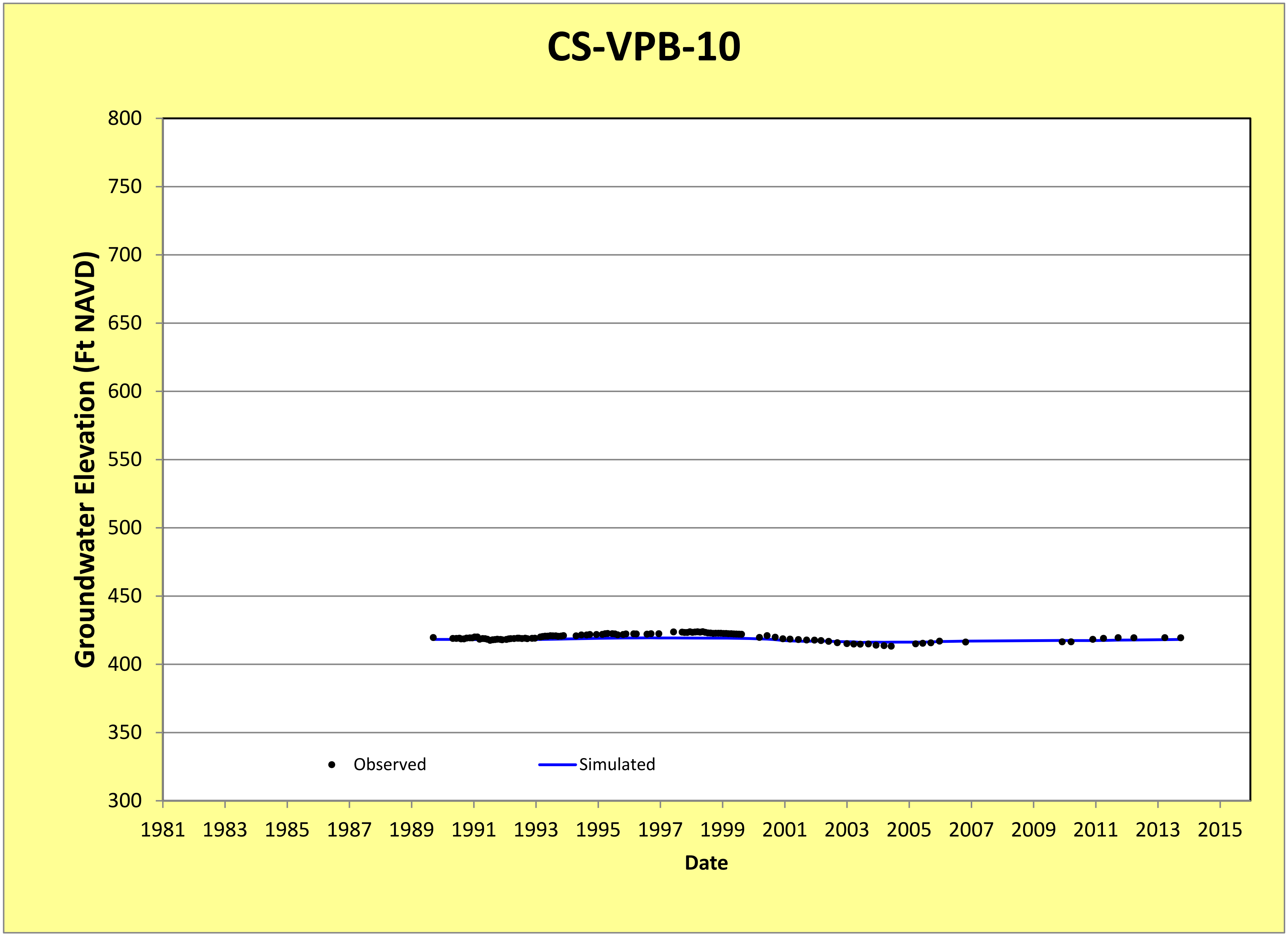
2003
2005
2007
2009
2011
2013
2015
Date

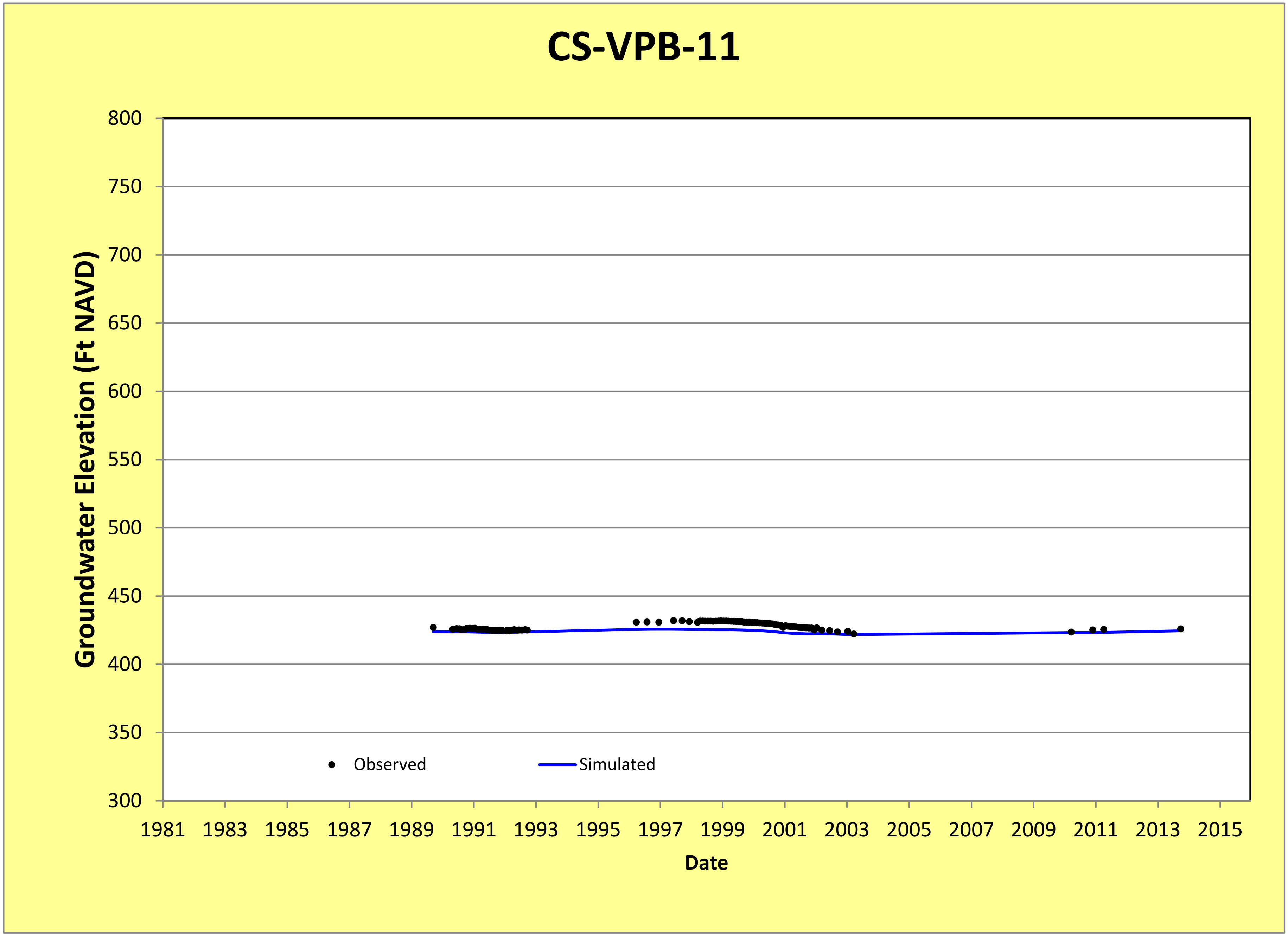


CS-VPB-08
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date

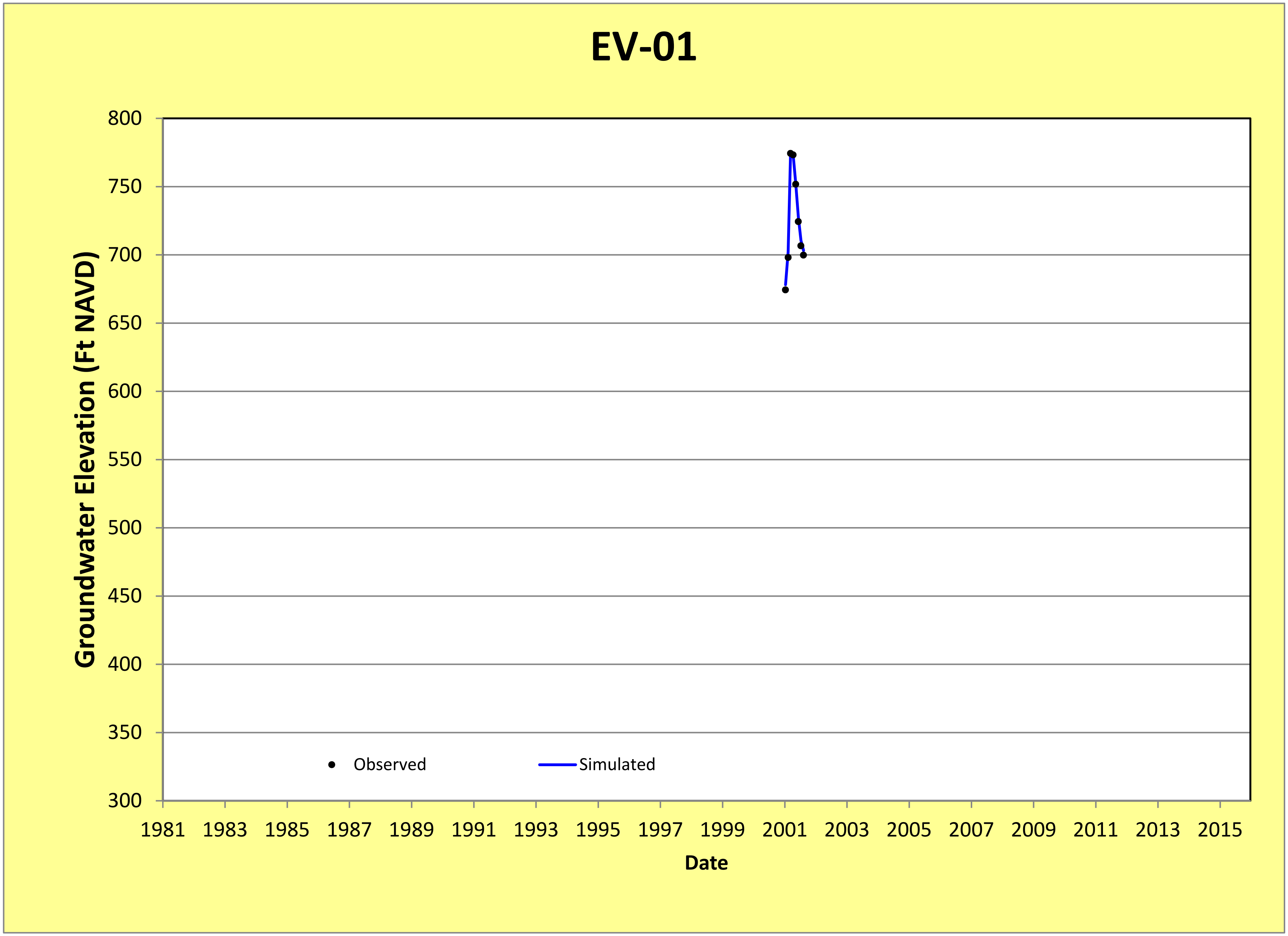

CS-VPB-09
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date



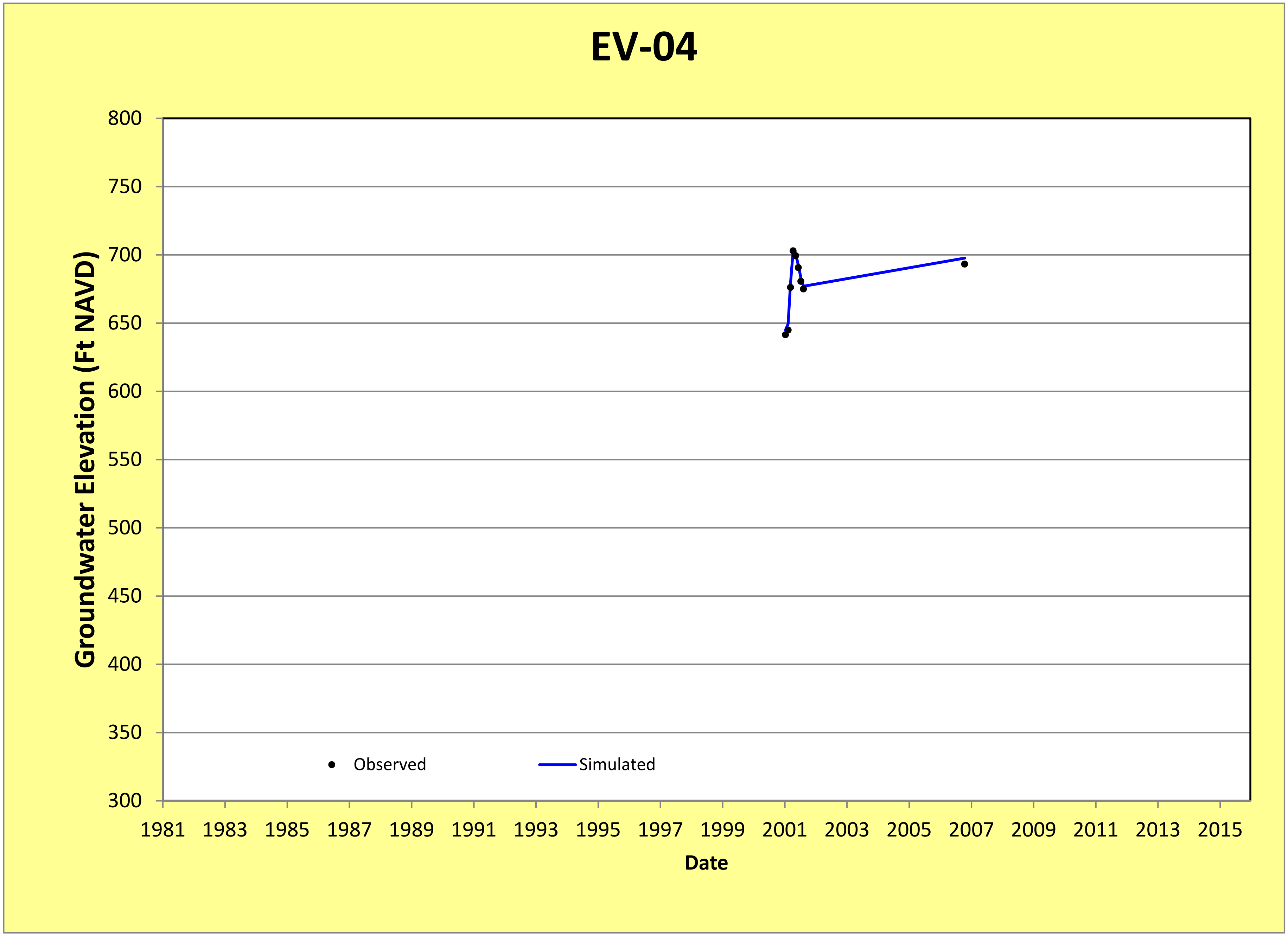
CS-VPB-10
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated

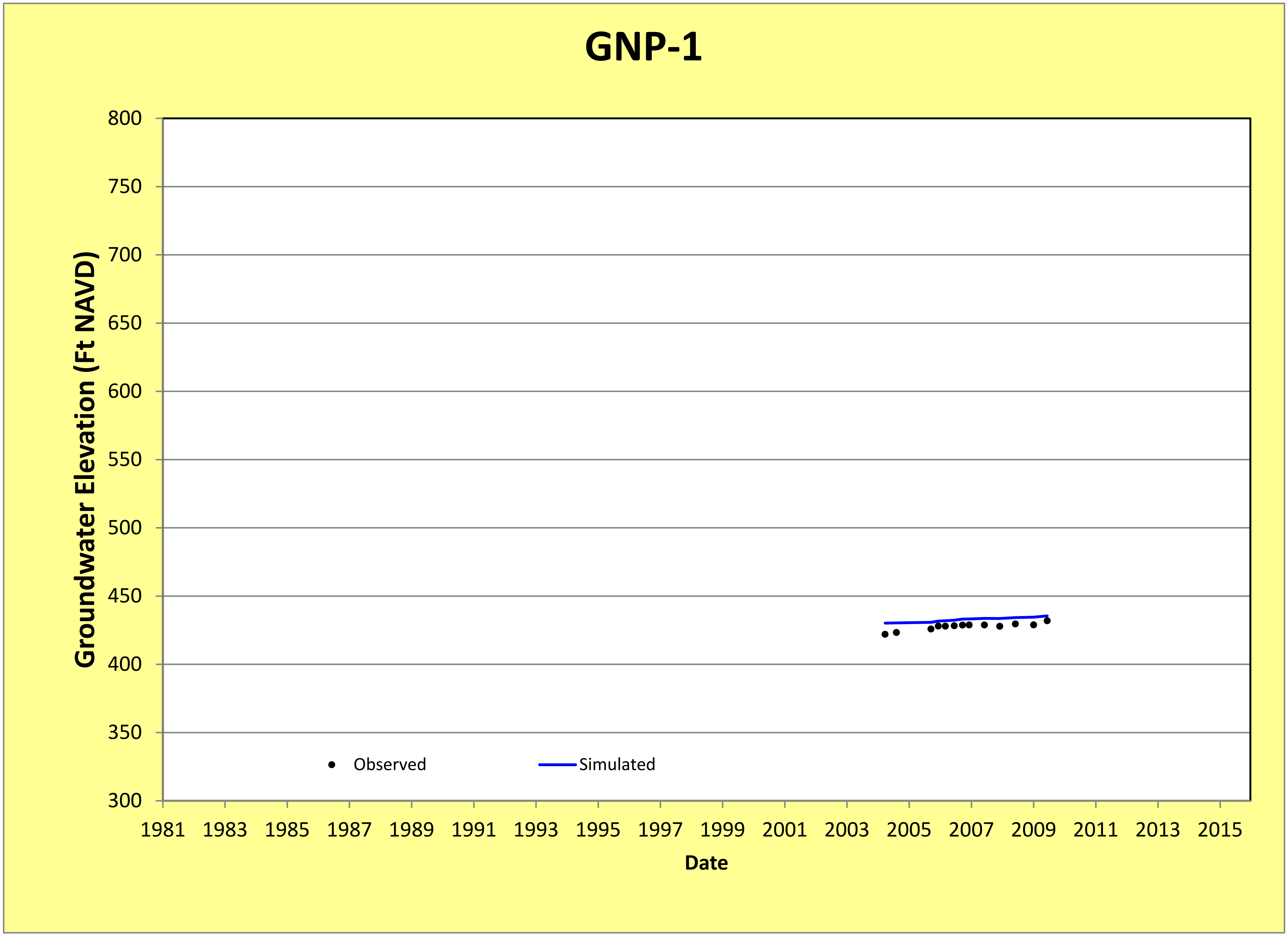


CS-VPB-11
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated

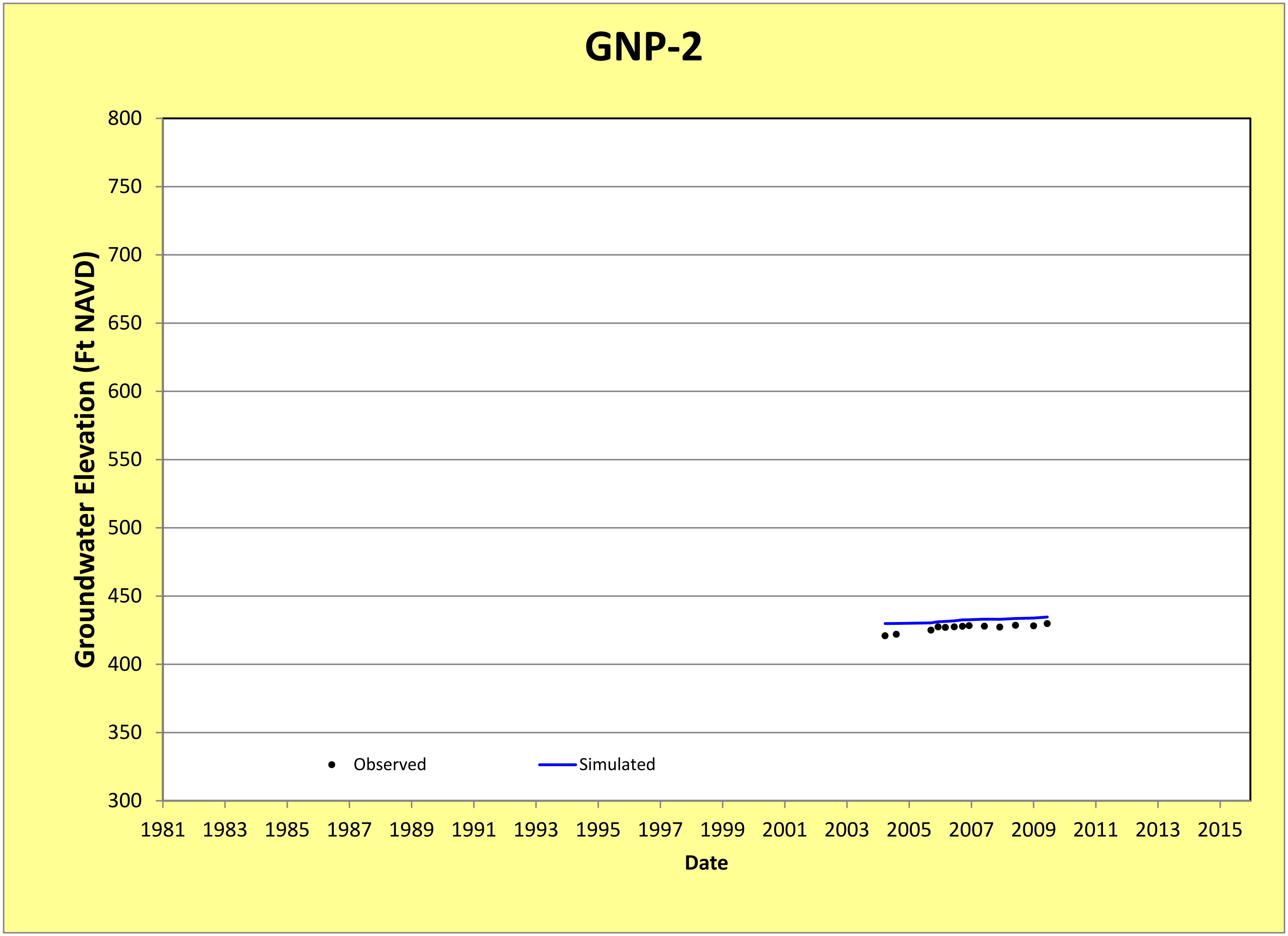


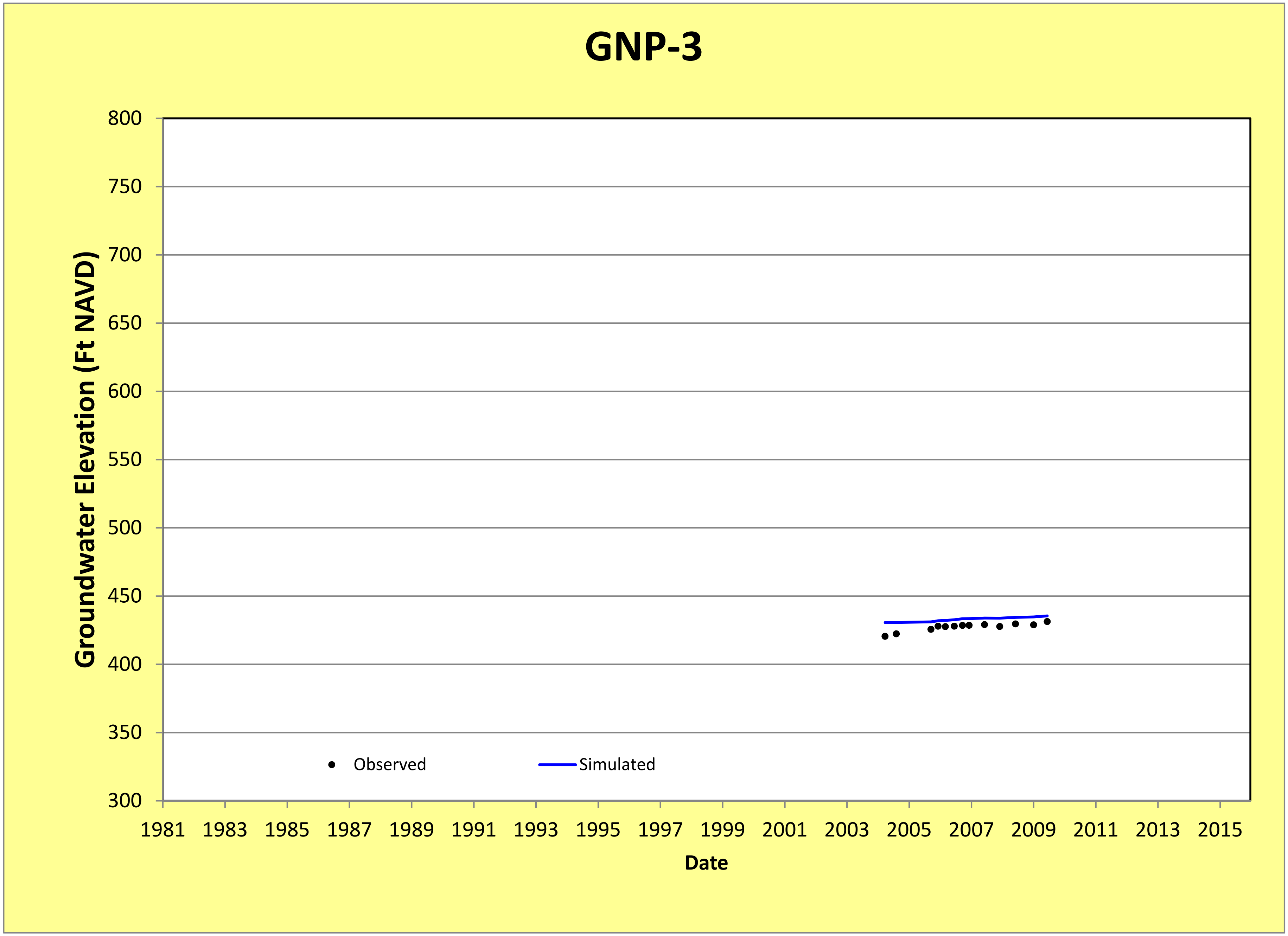
EV-01
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date


EV-04
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date



GNP-1
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date


GNP-2
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated


GNP-3
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
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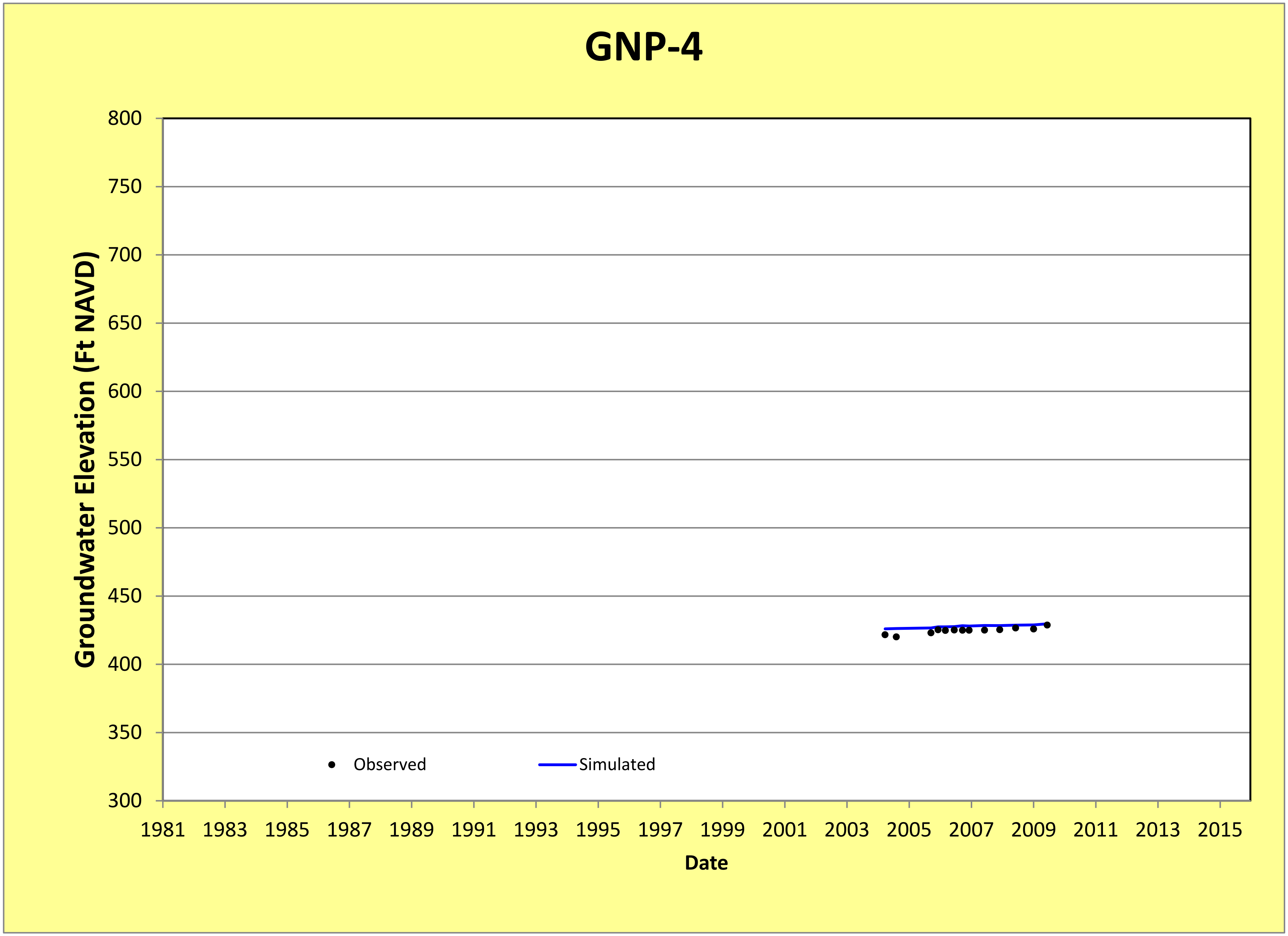
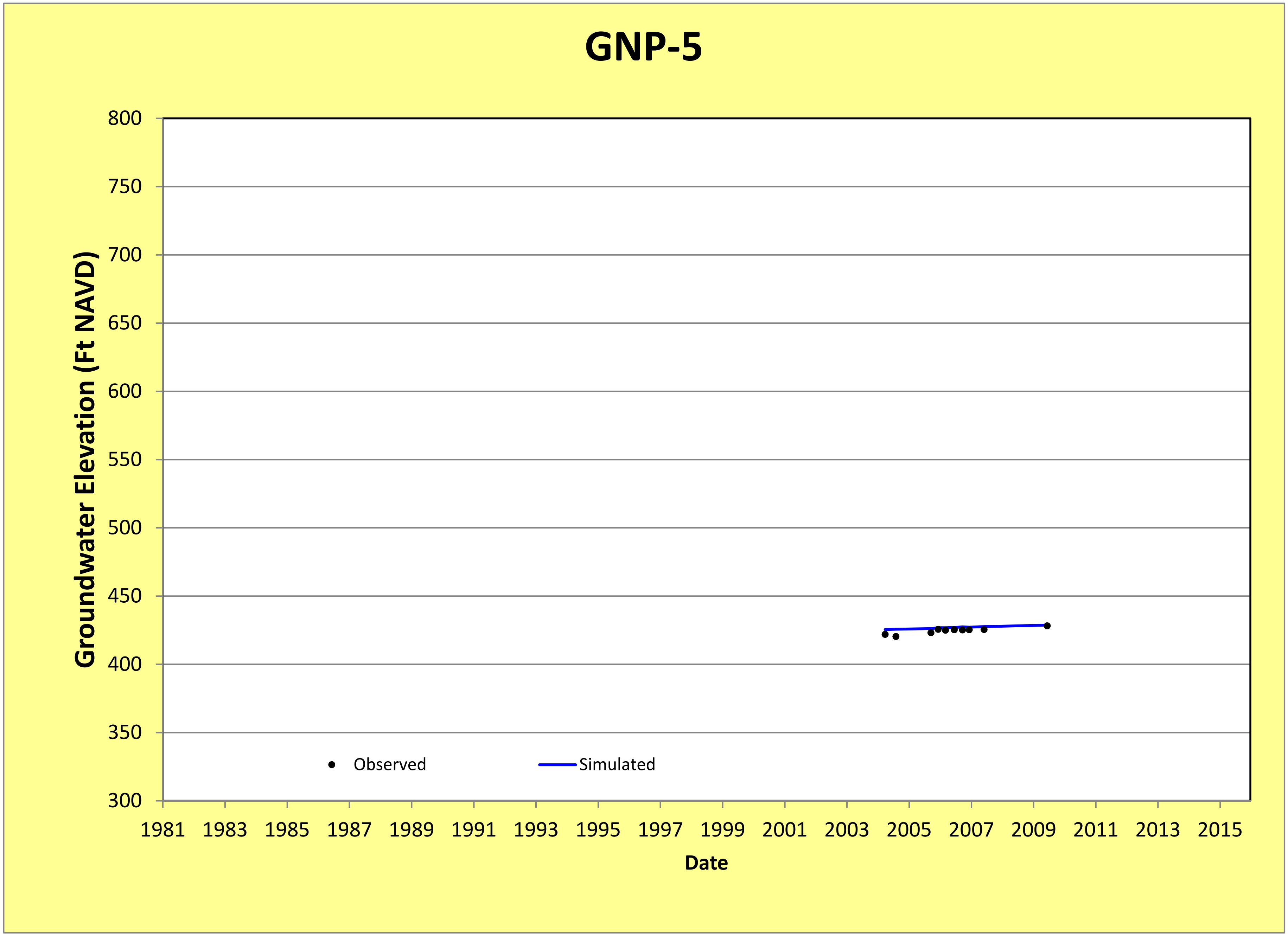
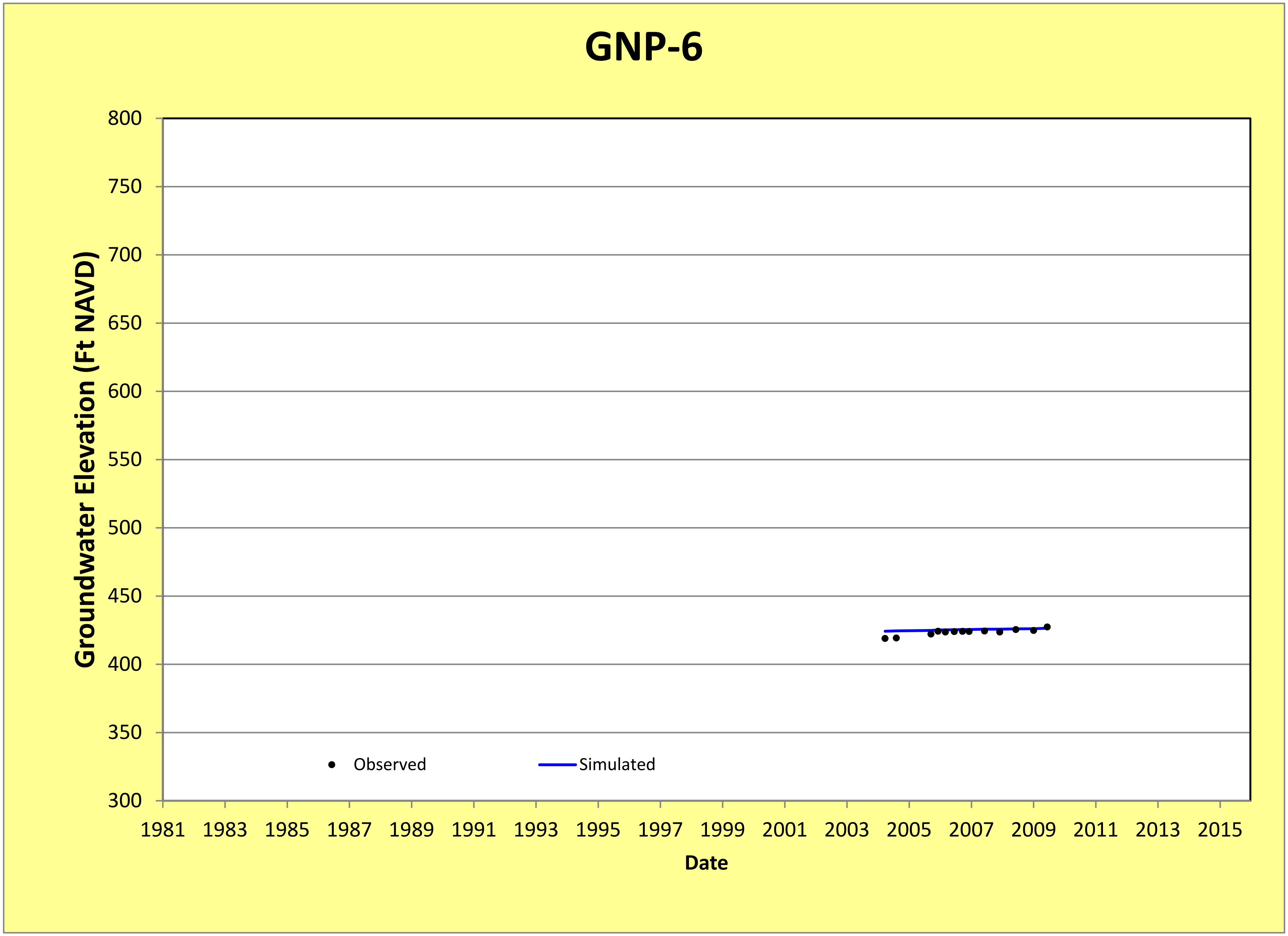
2003
2005
2007
2009
2011
2013
2015
Date



GNP-4
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date



GNP-5
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date



GNP-6
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
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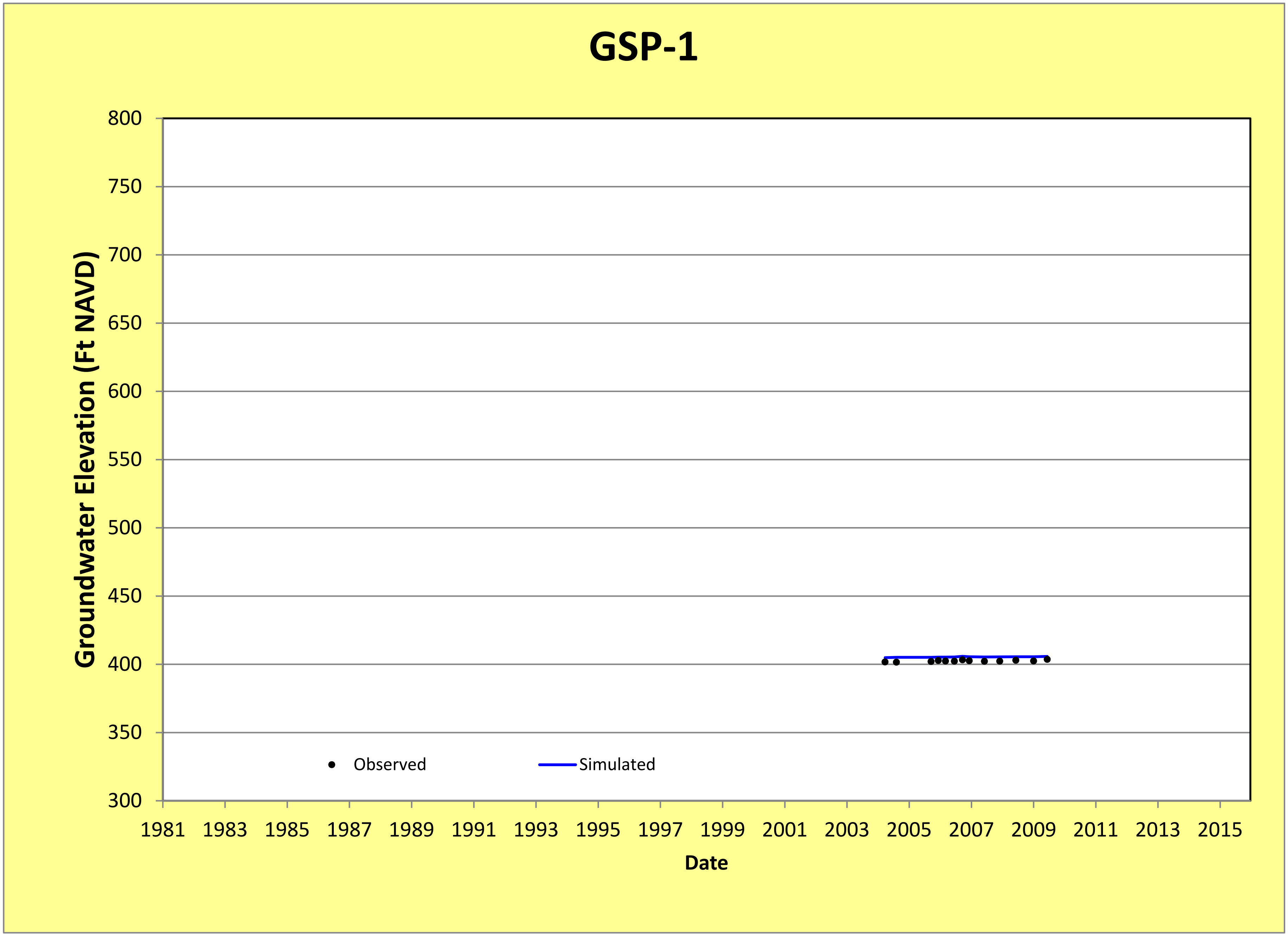
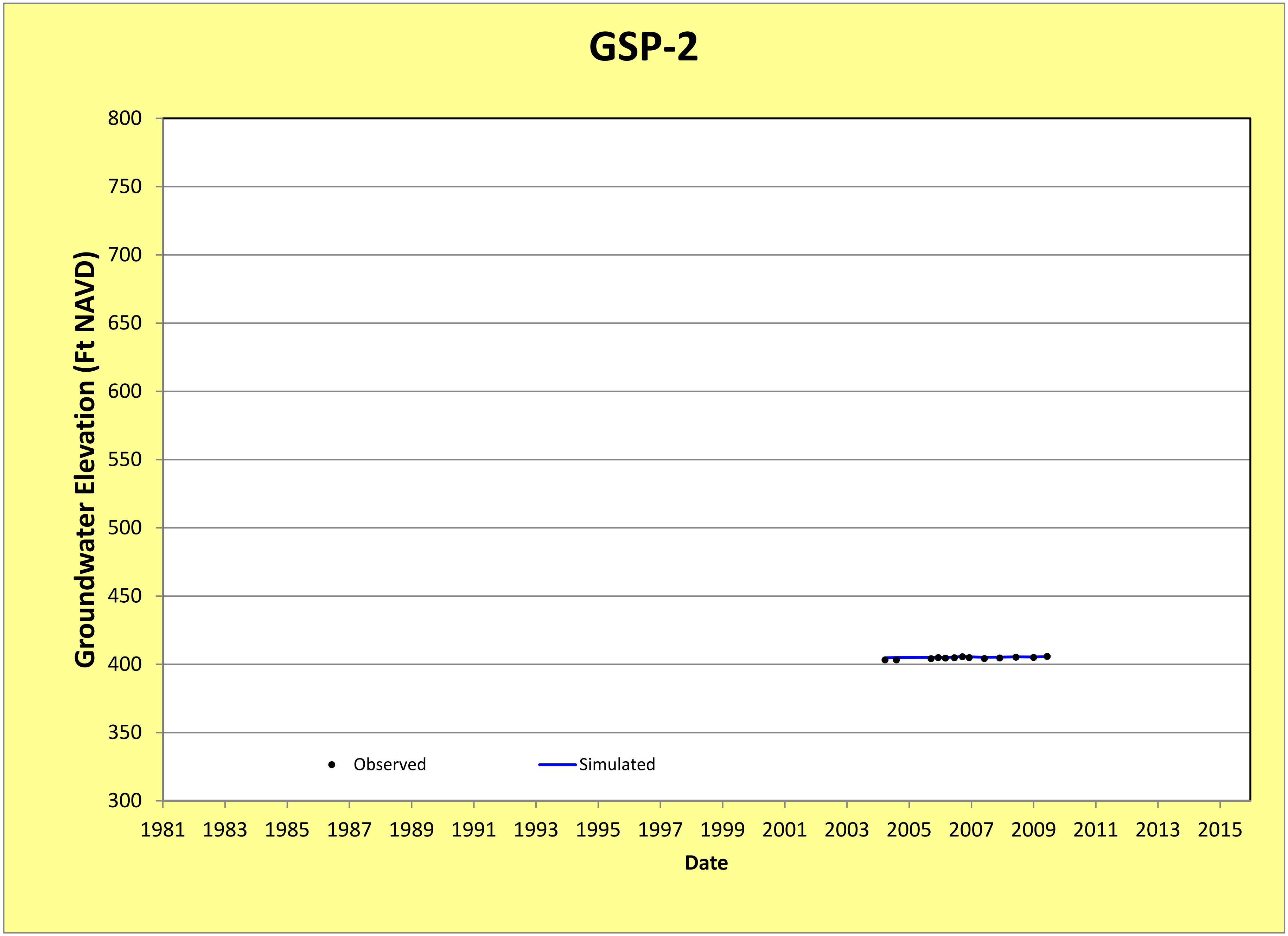
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date



GSP-1
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date



GSP-2
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
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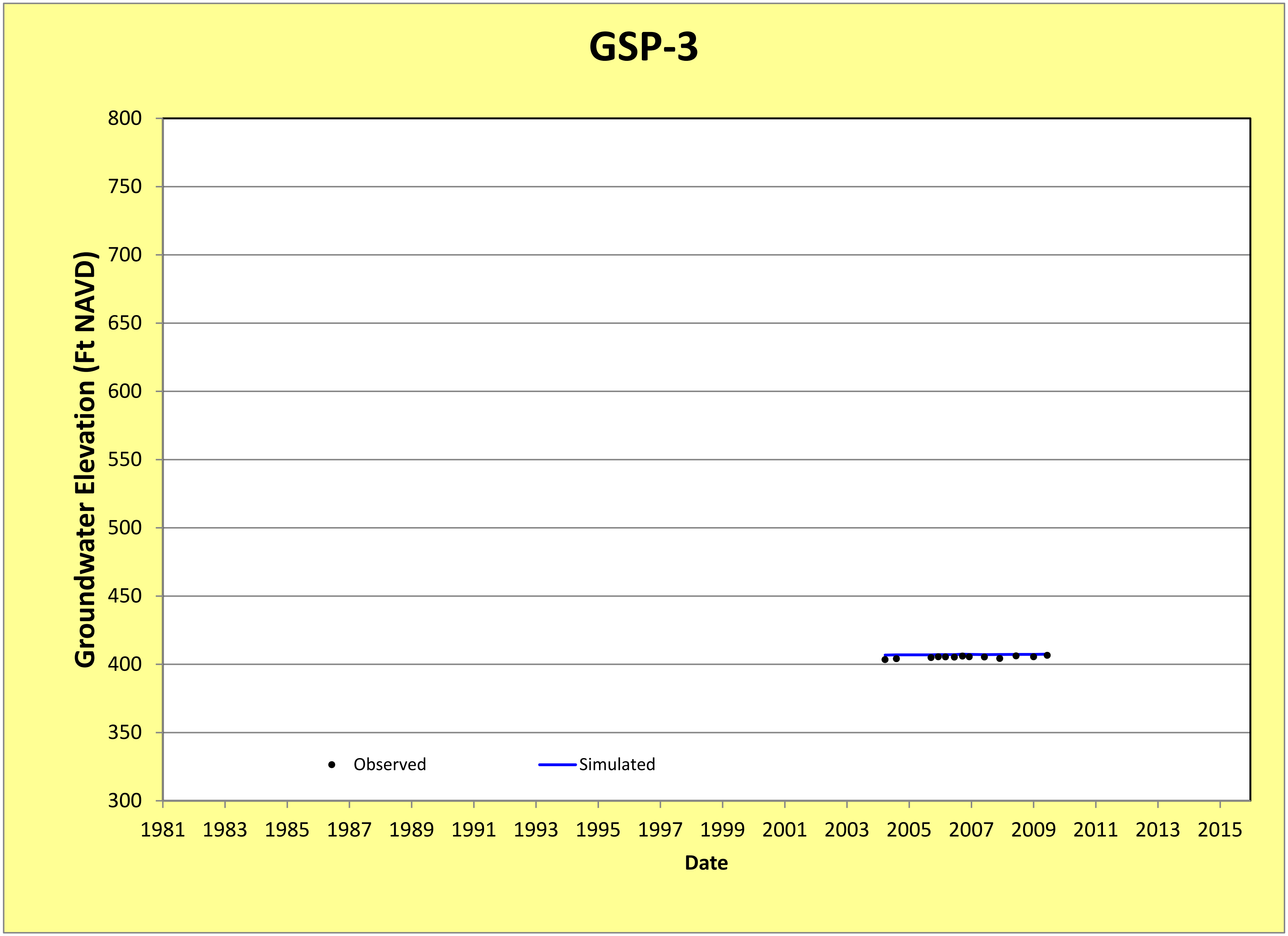
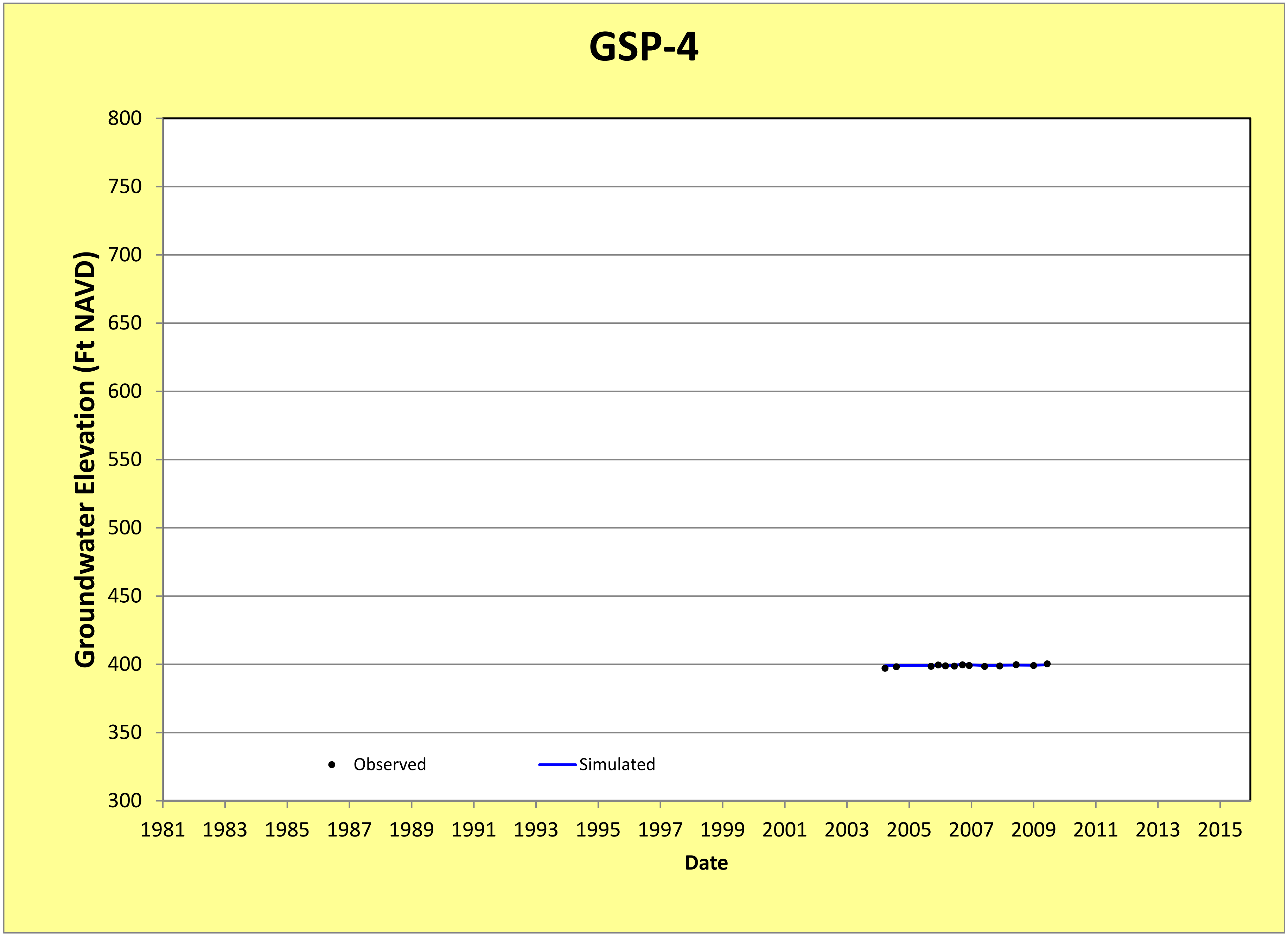
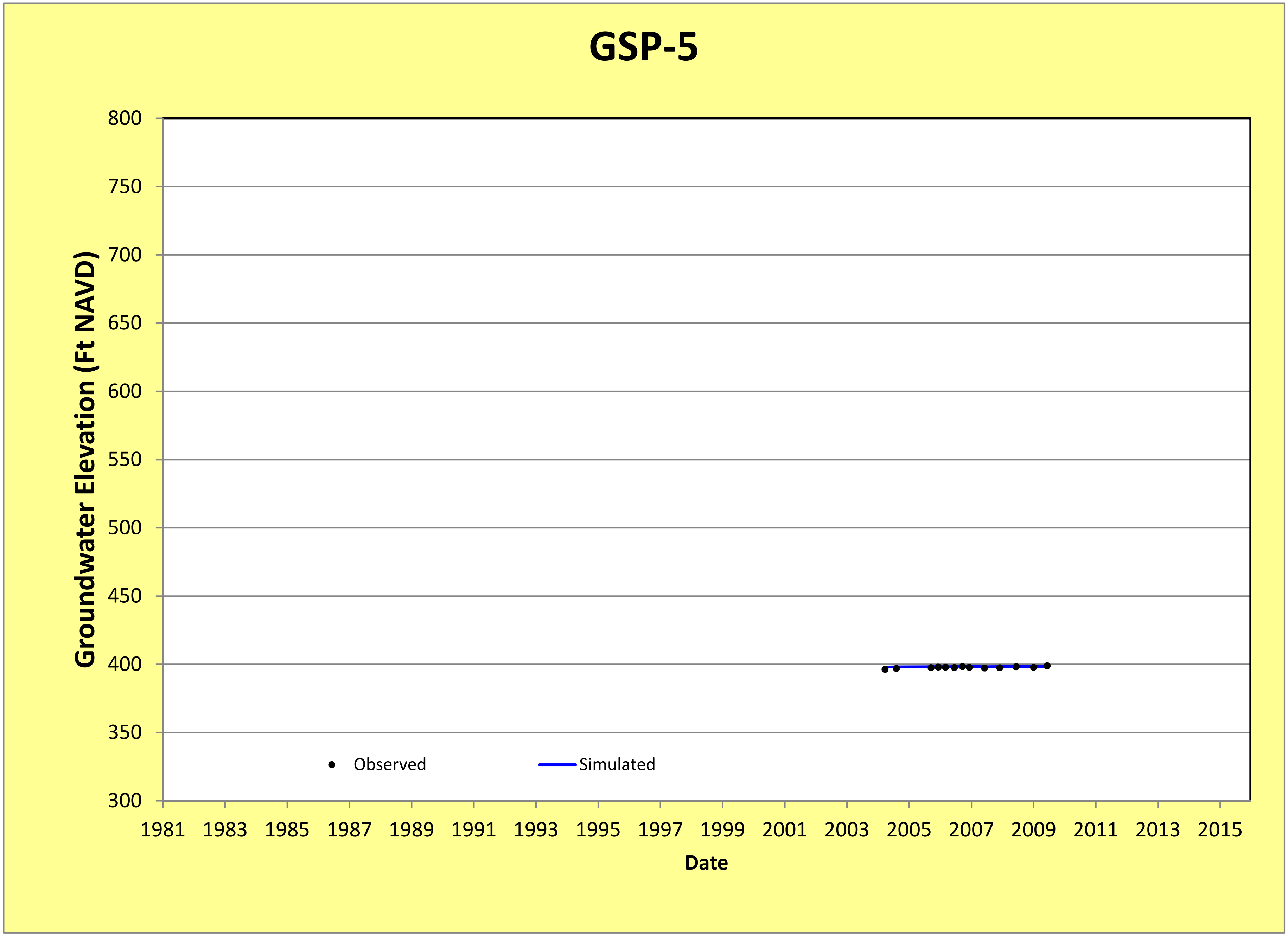
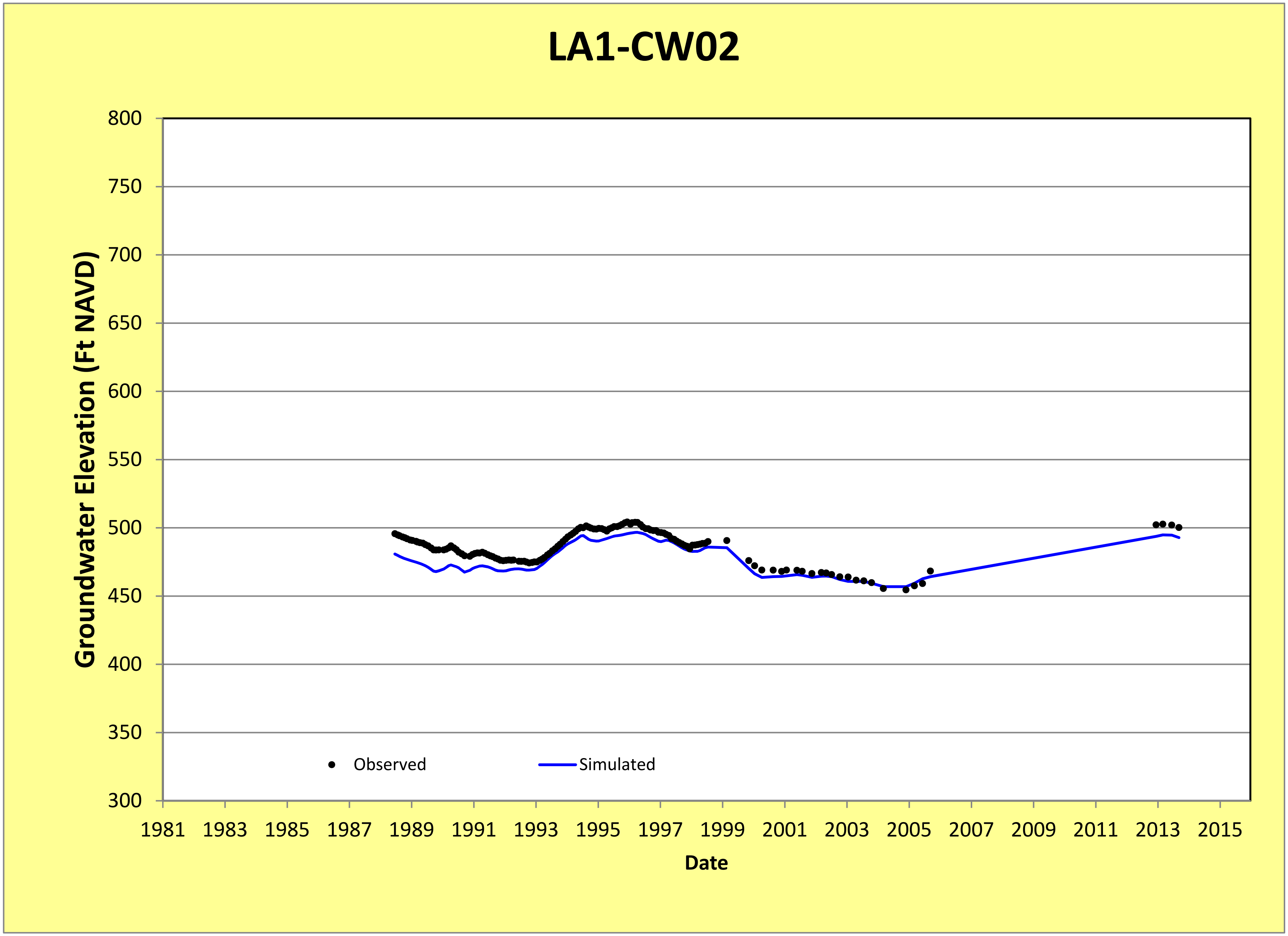
2001
2003
2005
2007
2009
2011
2013
2015
Date



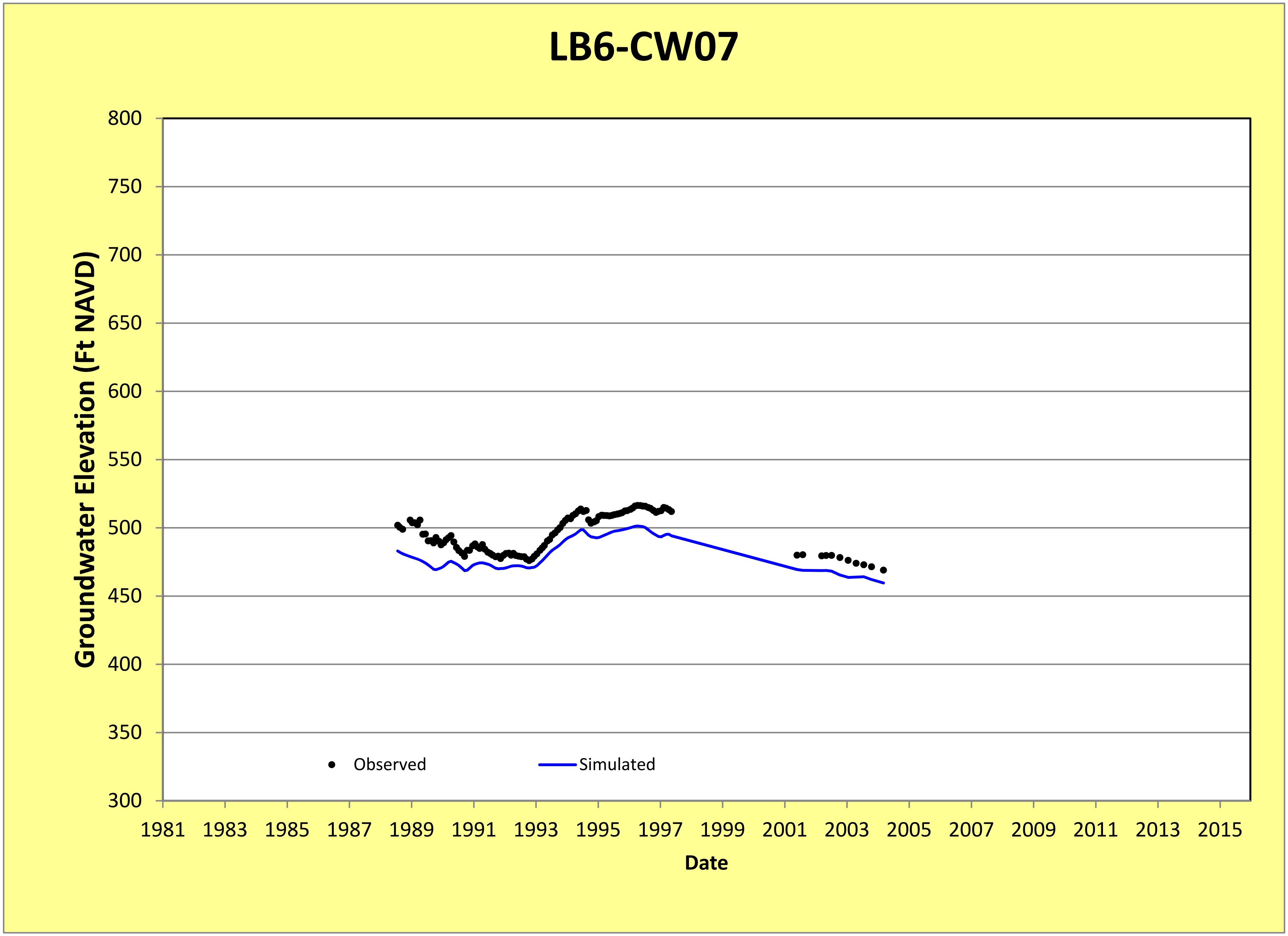
GSP-3
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date

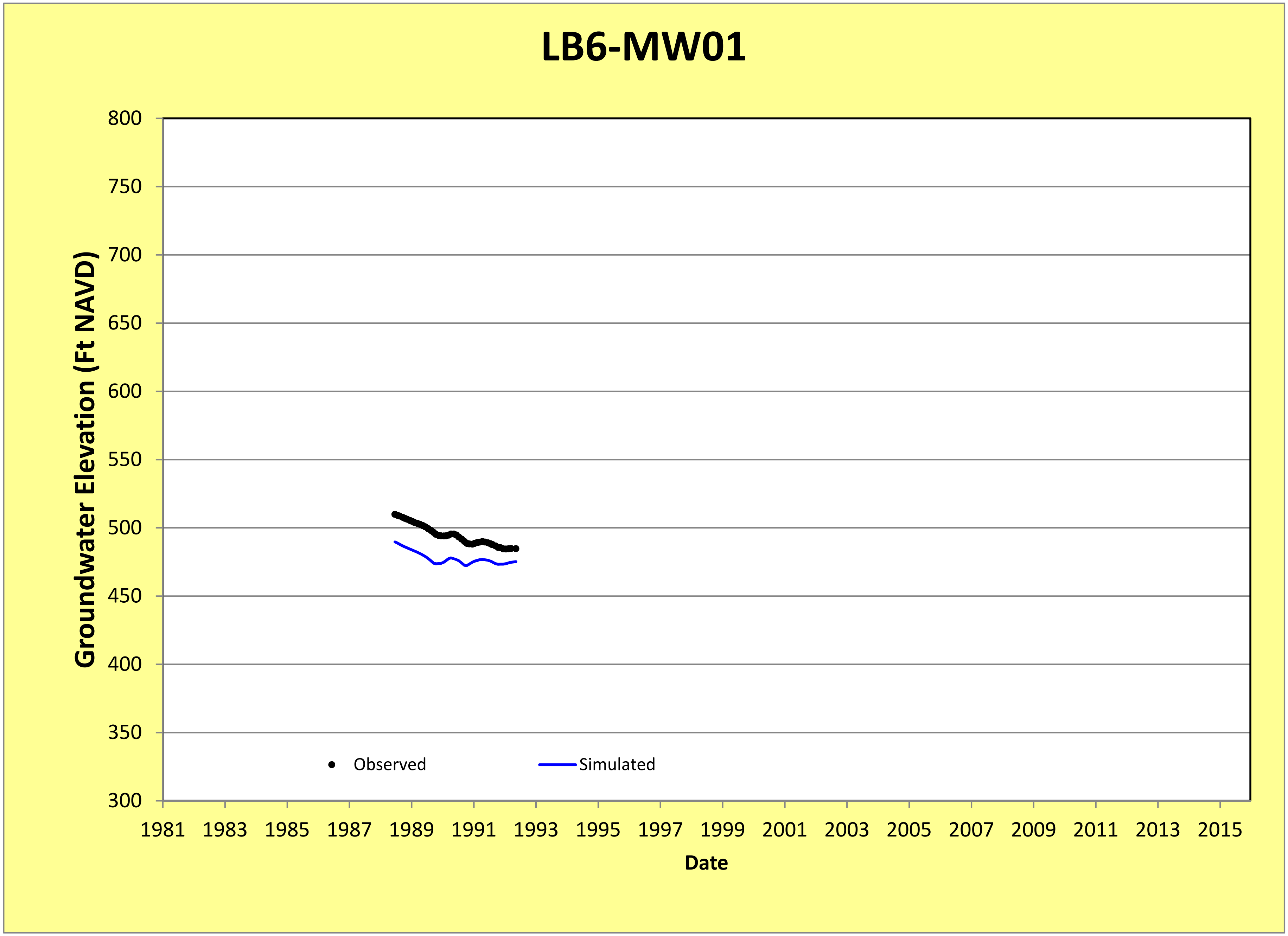

GSP-4
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date

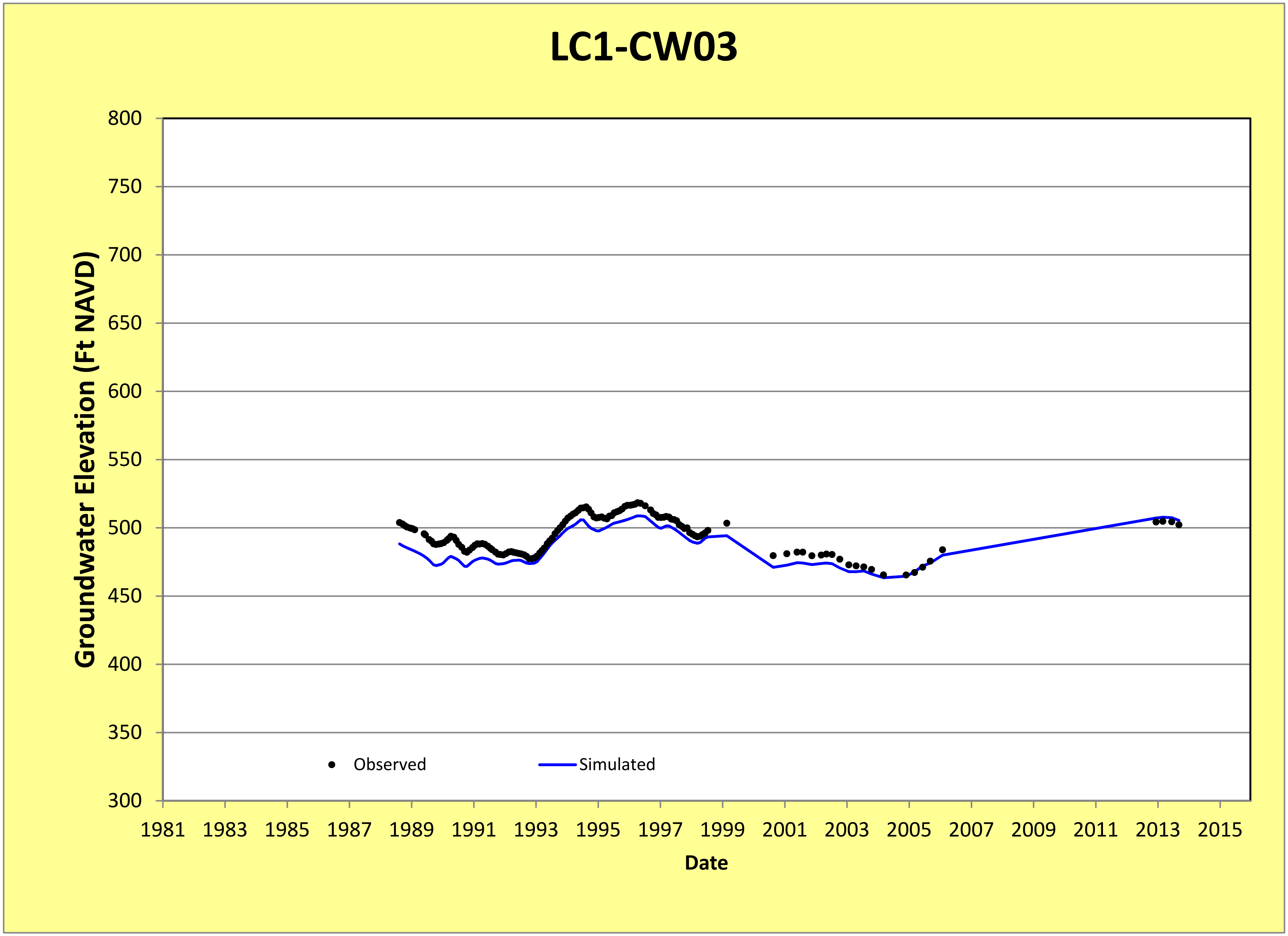

GSP-5
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date

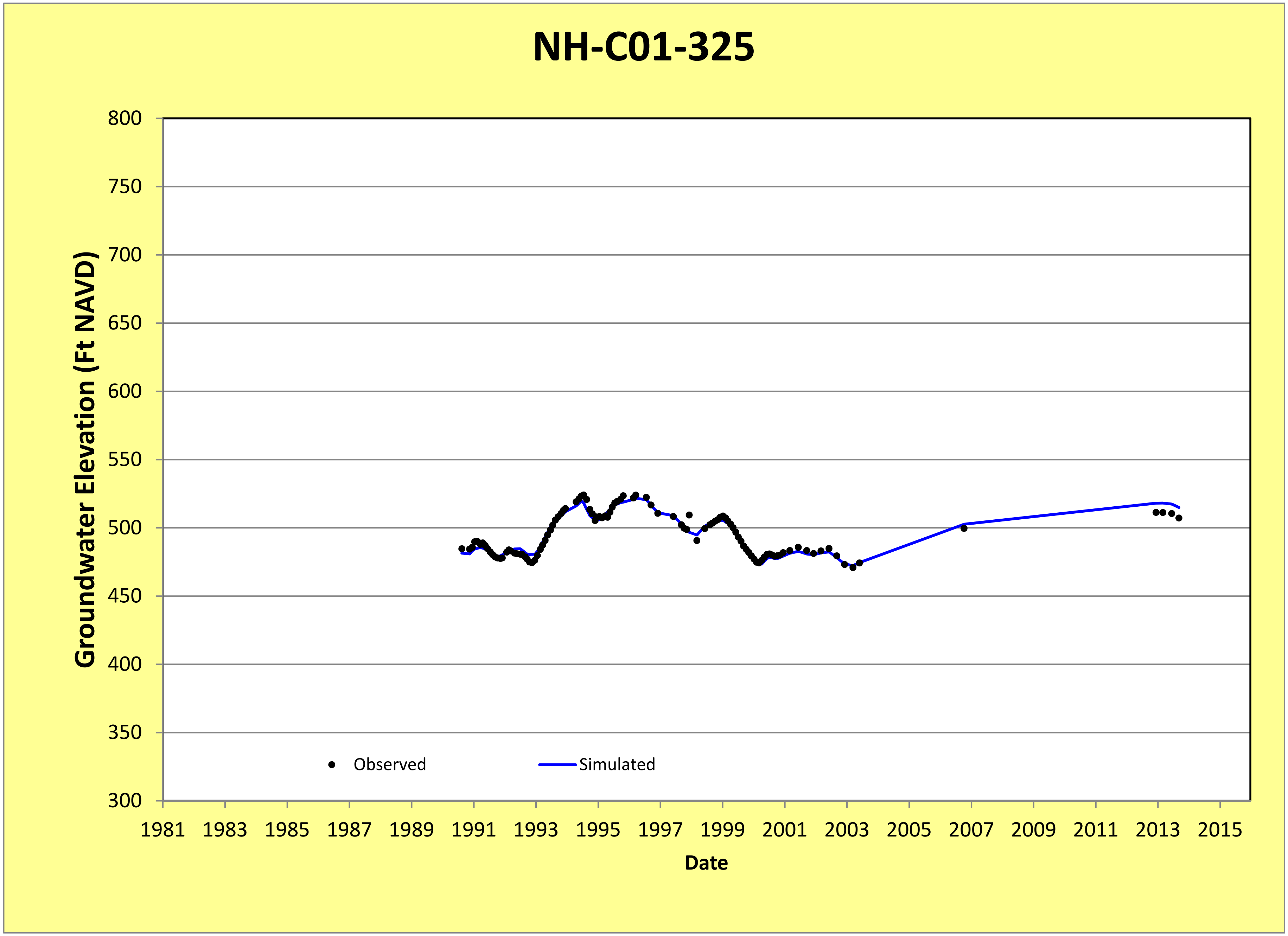


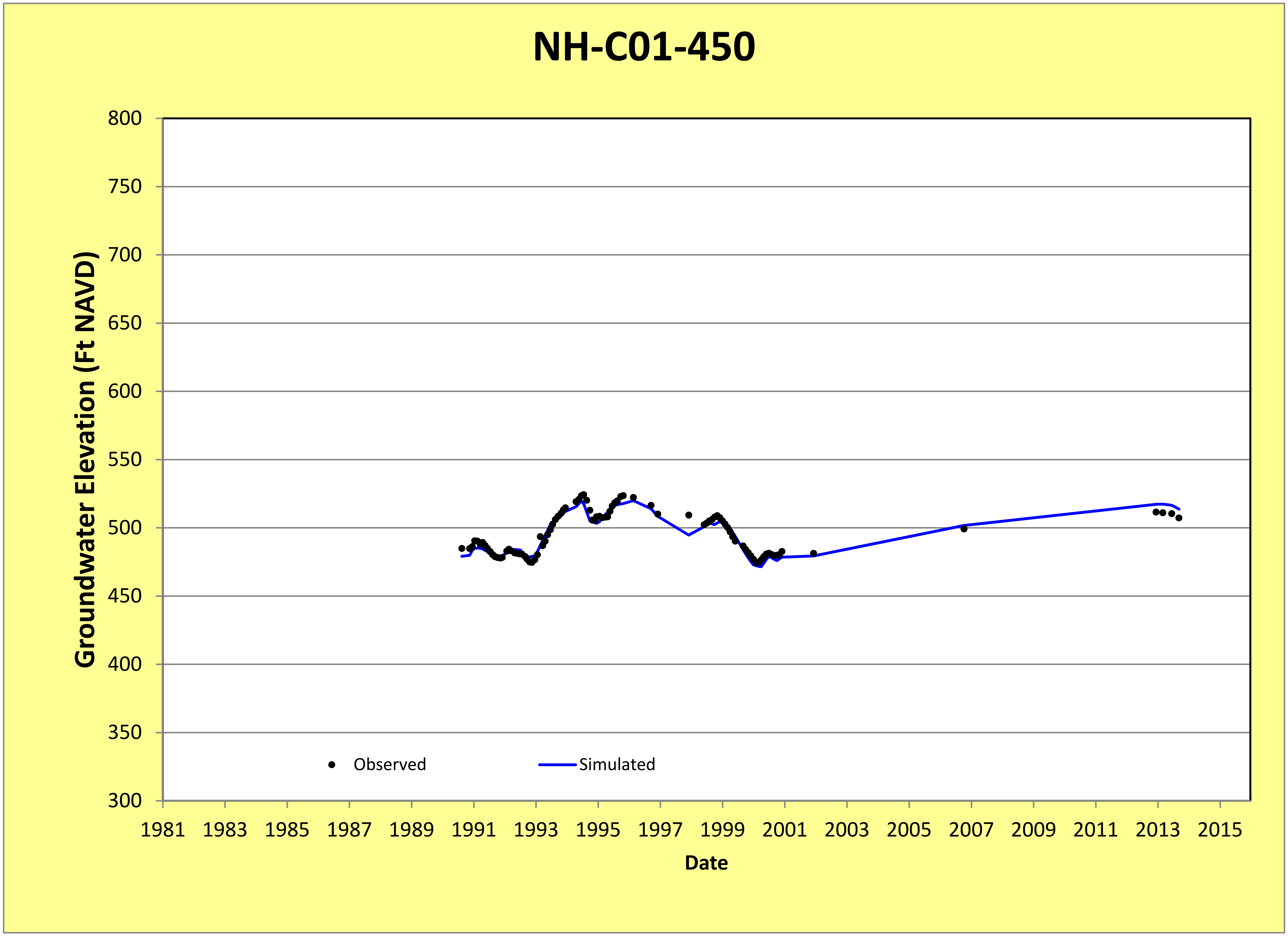
LA1-CW02
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date


LB6-CW07
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date

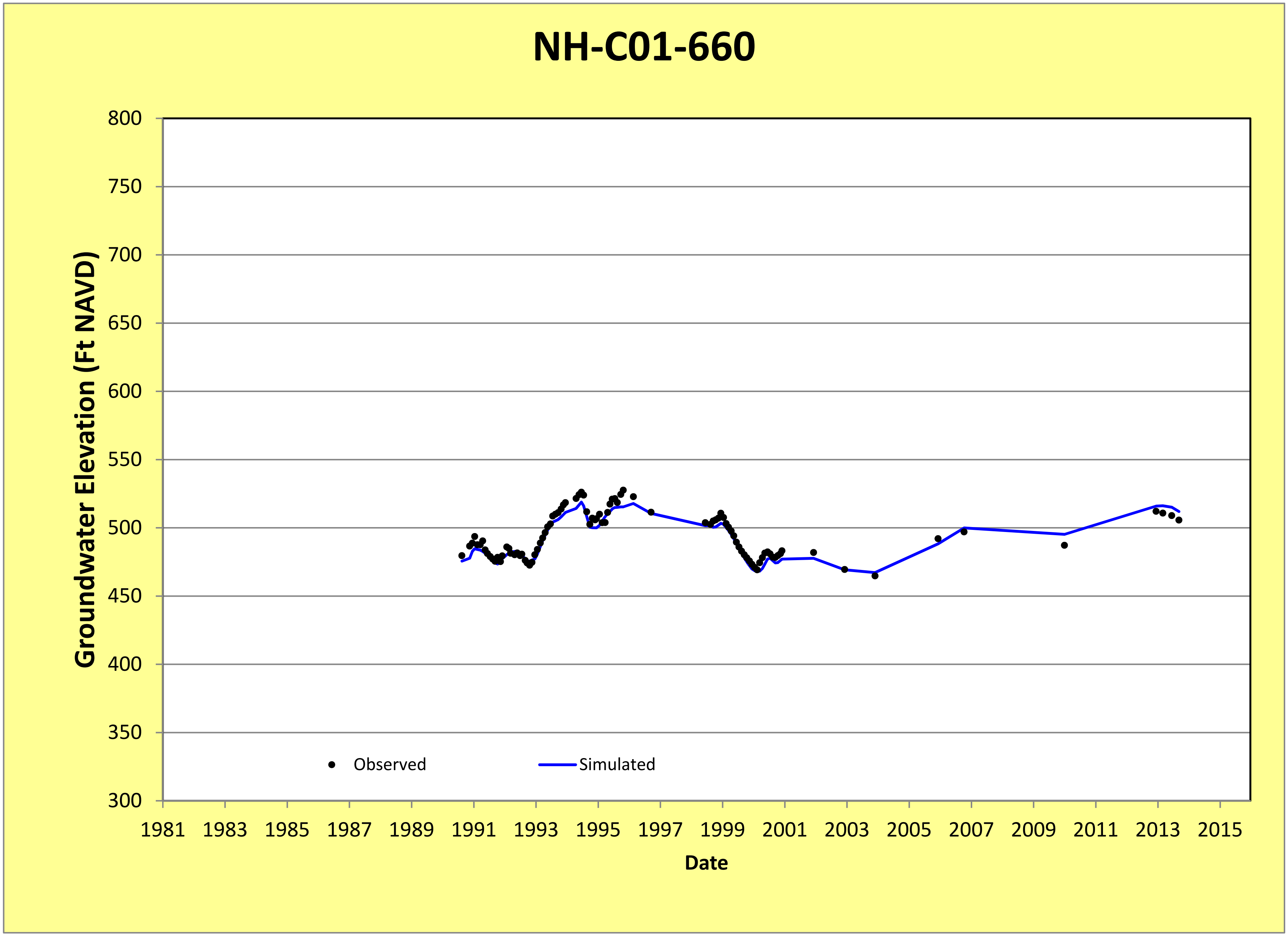

LB6-MW01
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated


LC1-CW03
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated

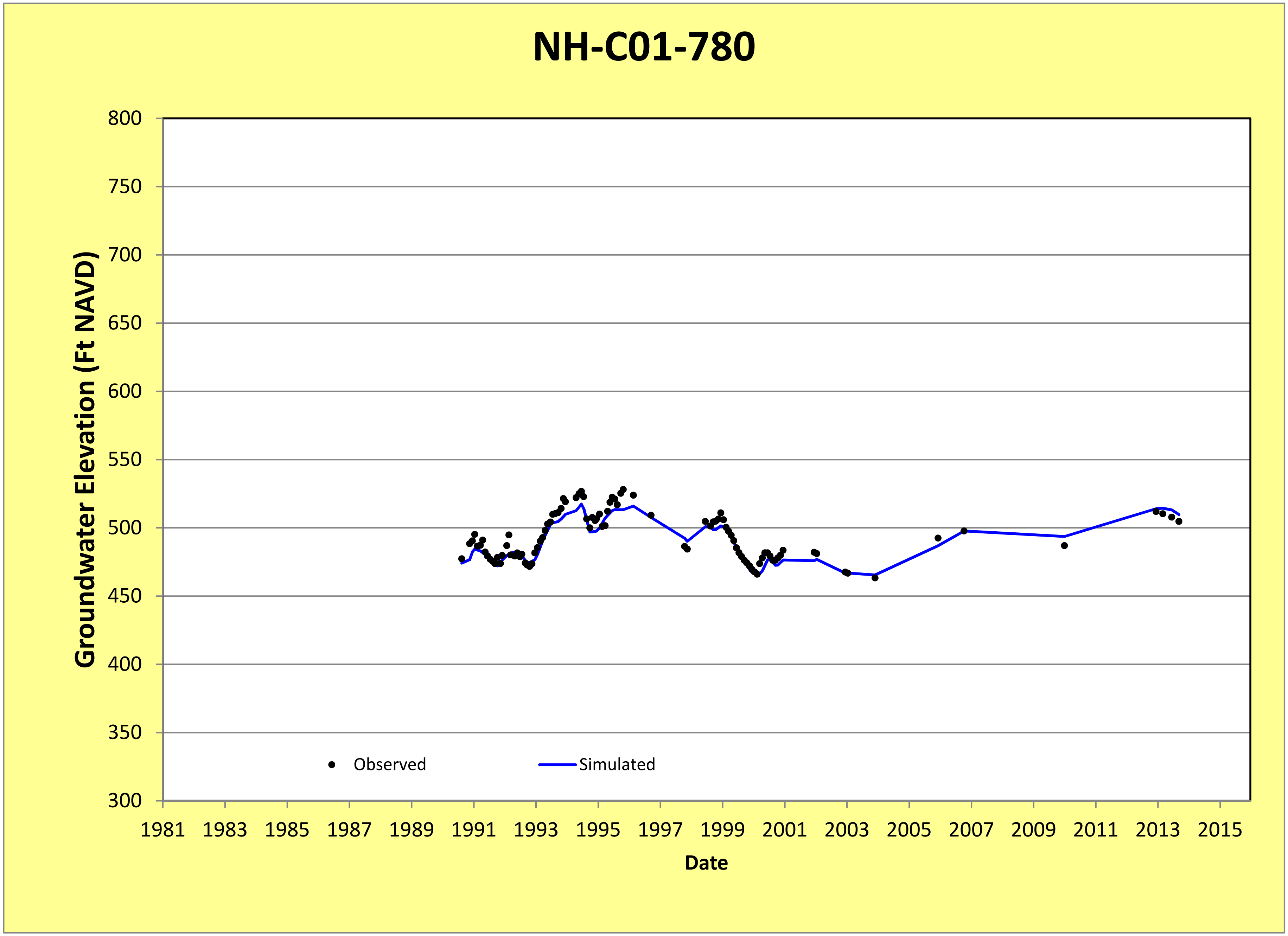

NH-C01-325
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated



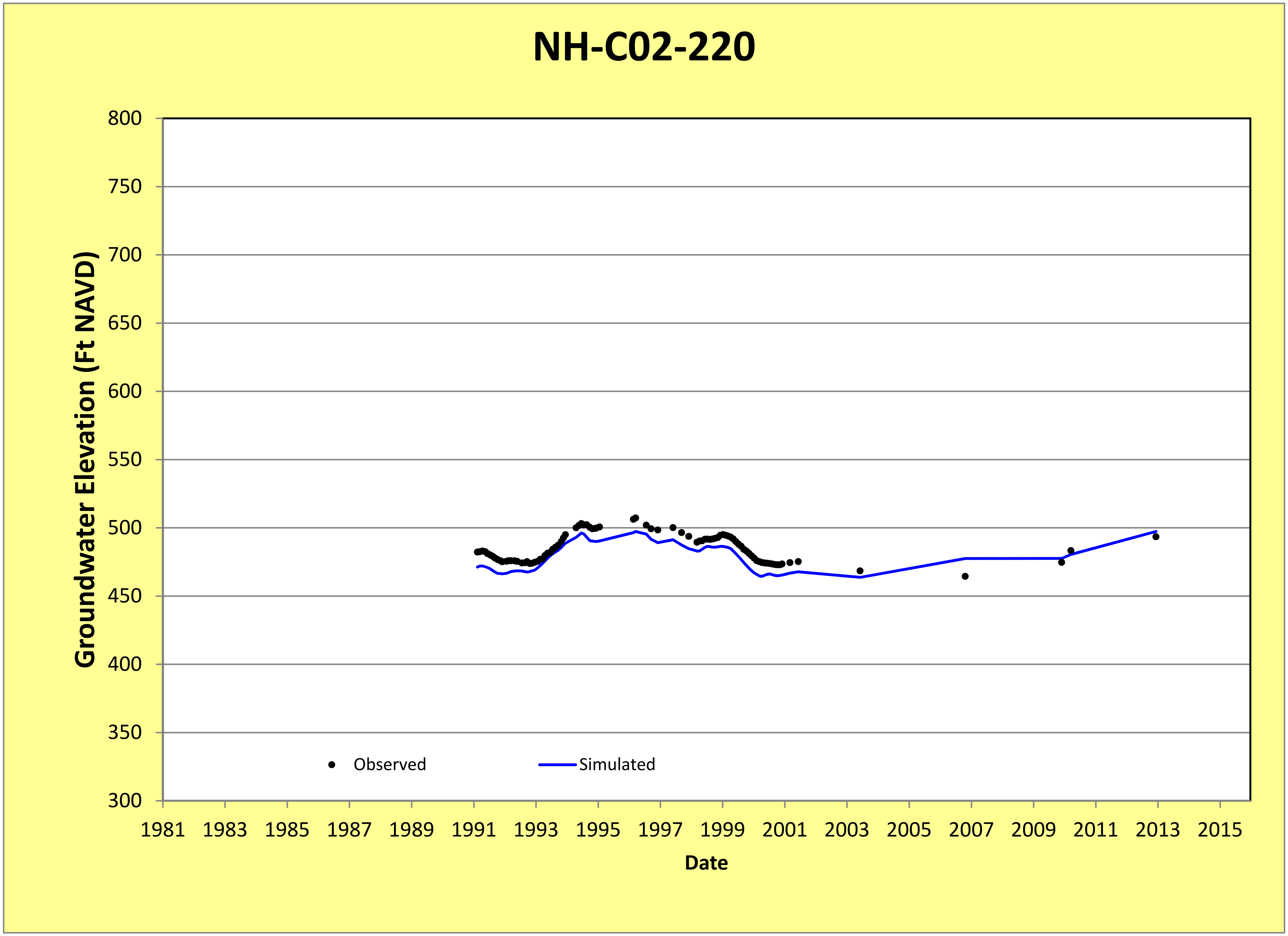
NH-C01-450
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated



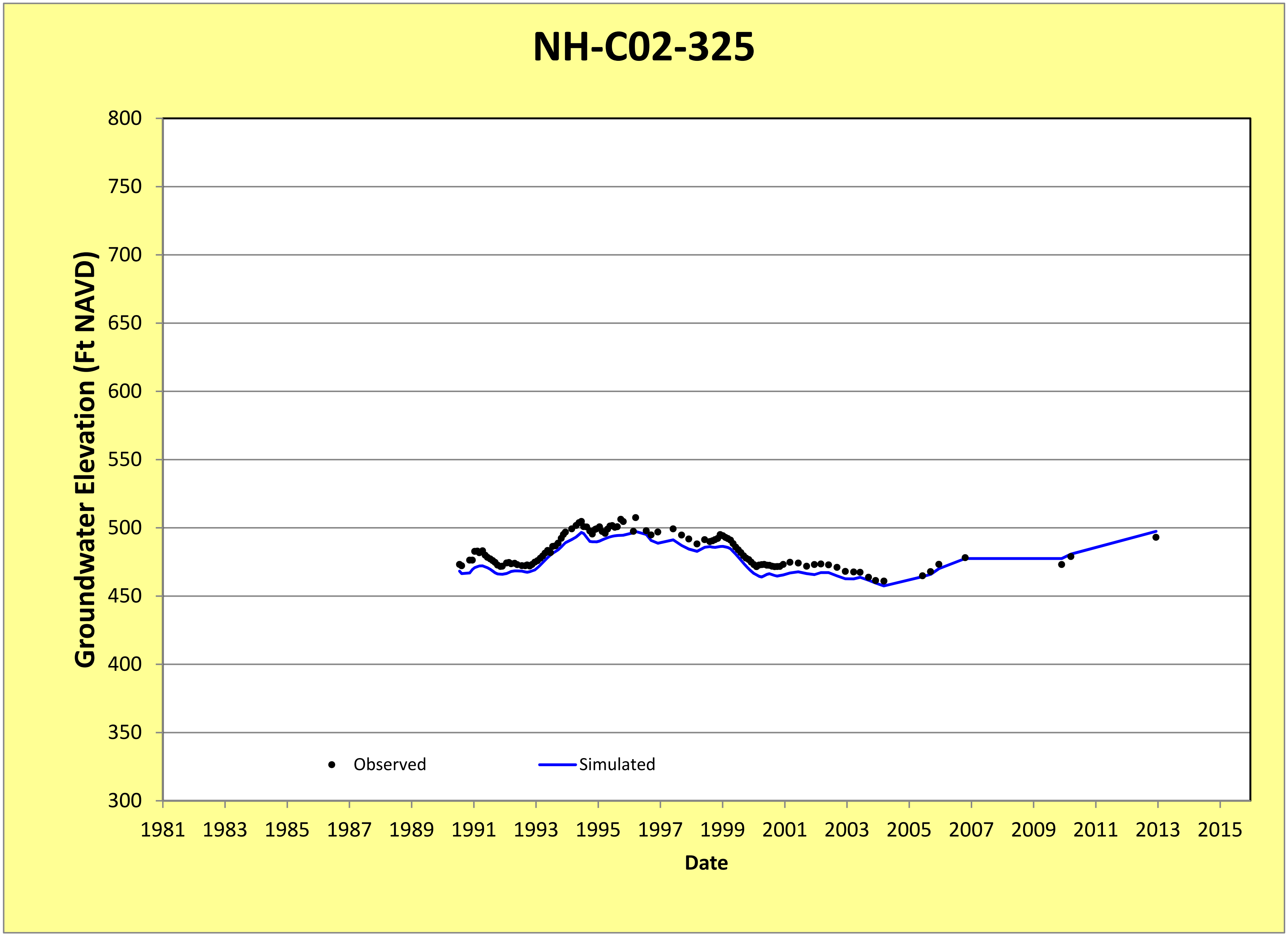
NH-C01-660
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date



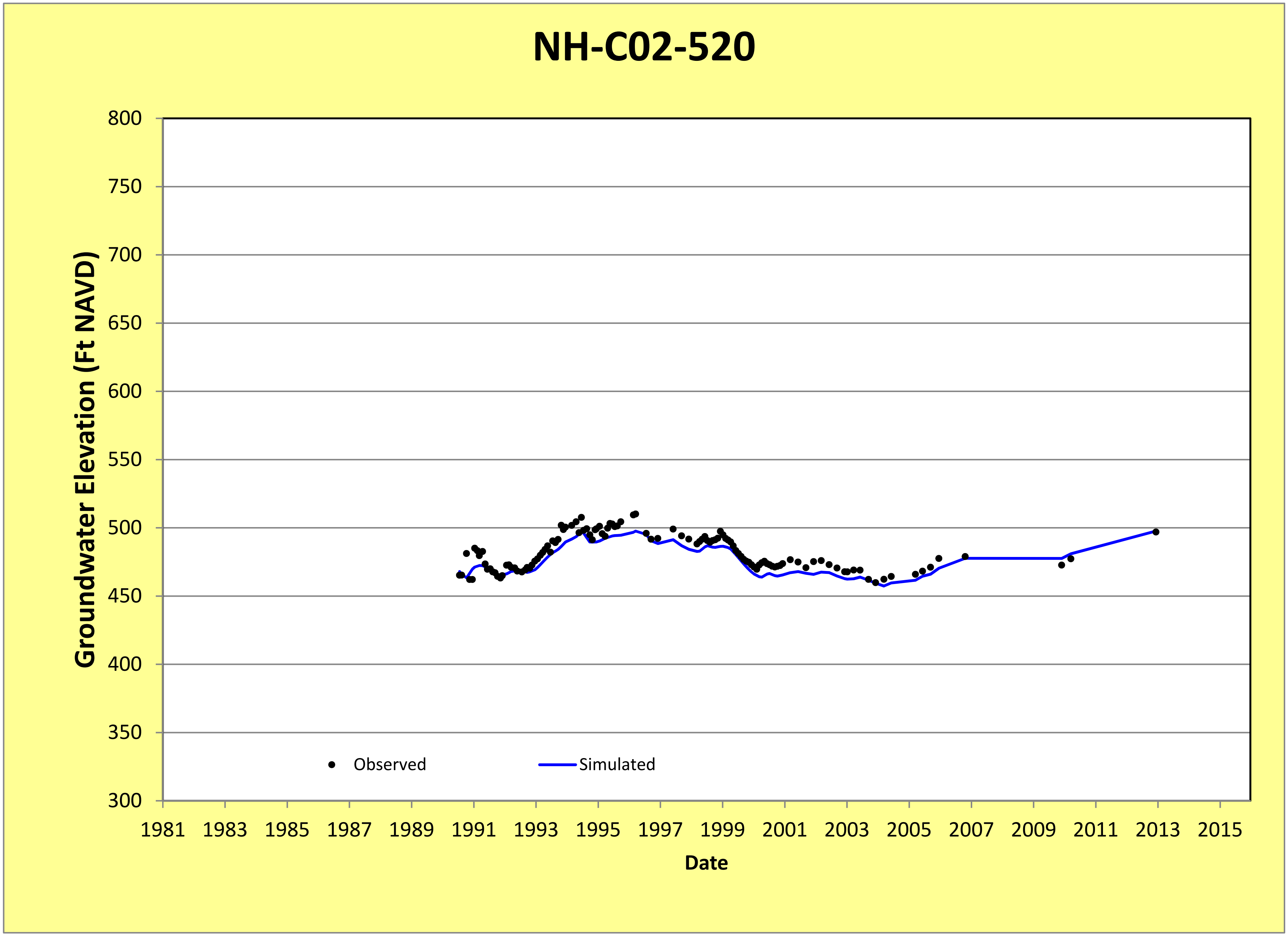
NH-C01-780
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated



NH-C02-220
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date



NH-C02-325
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date


NH-C02-520
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
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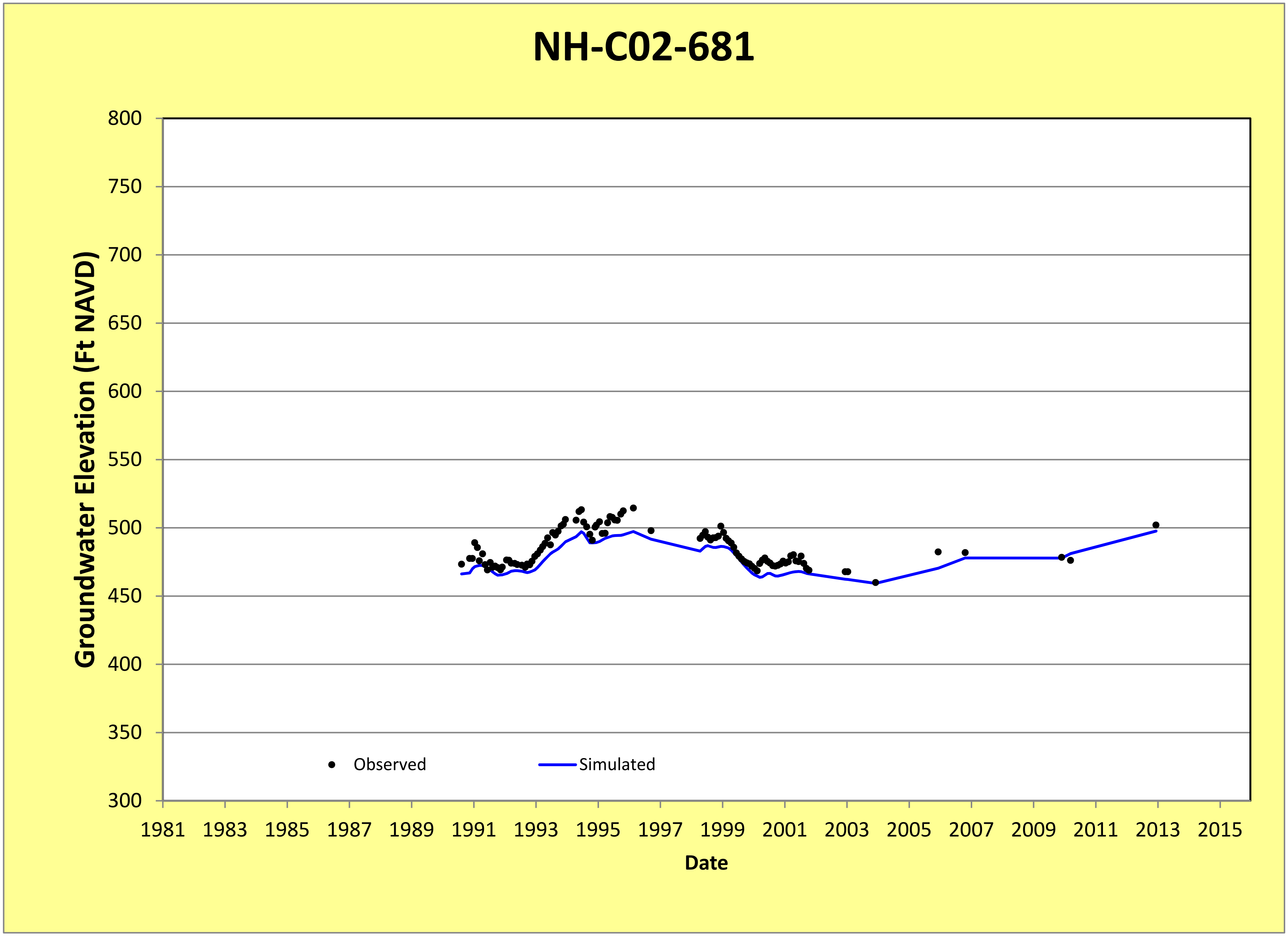
2003
2005
2007
2009
2011
2013
2015
Date



NH-C02-681
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
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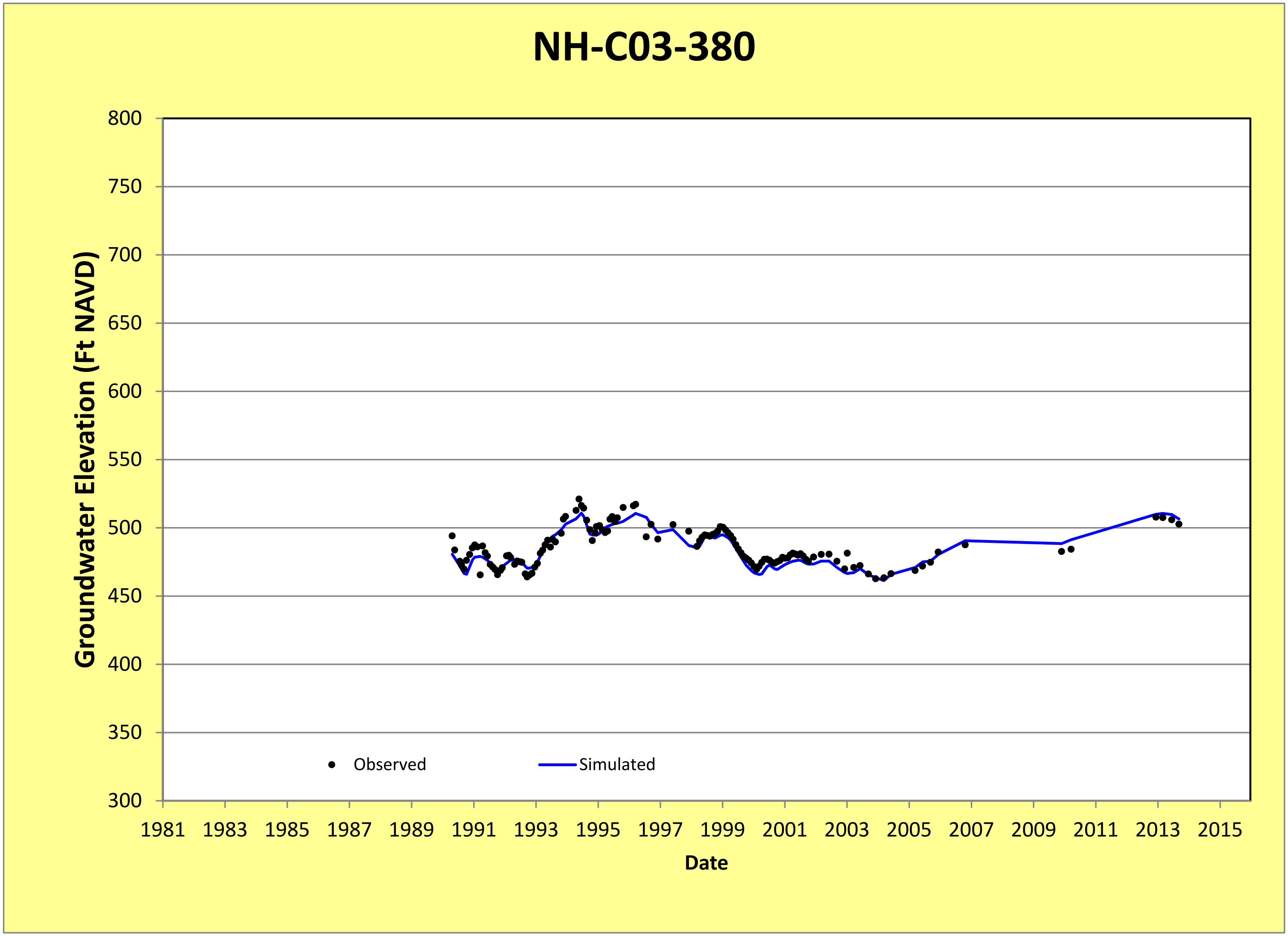
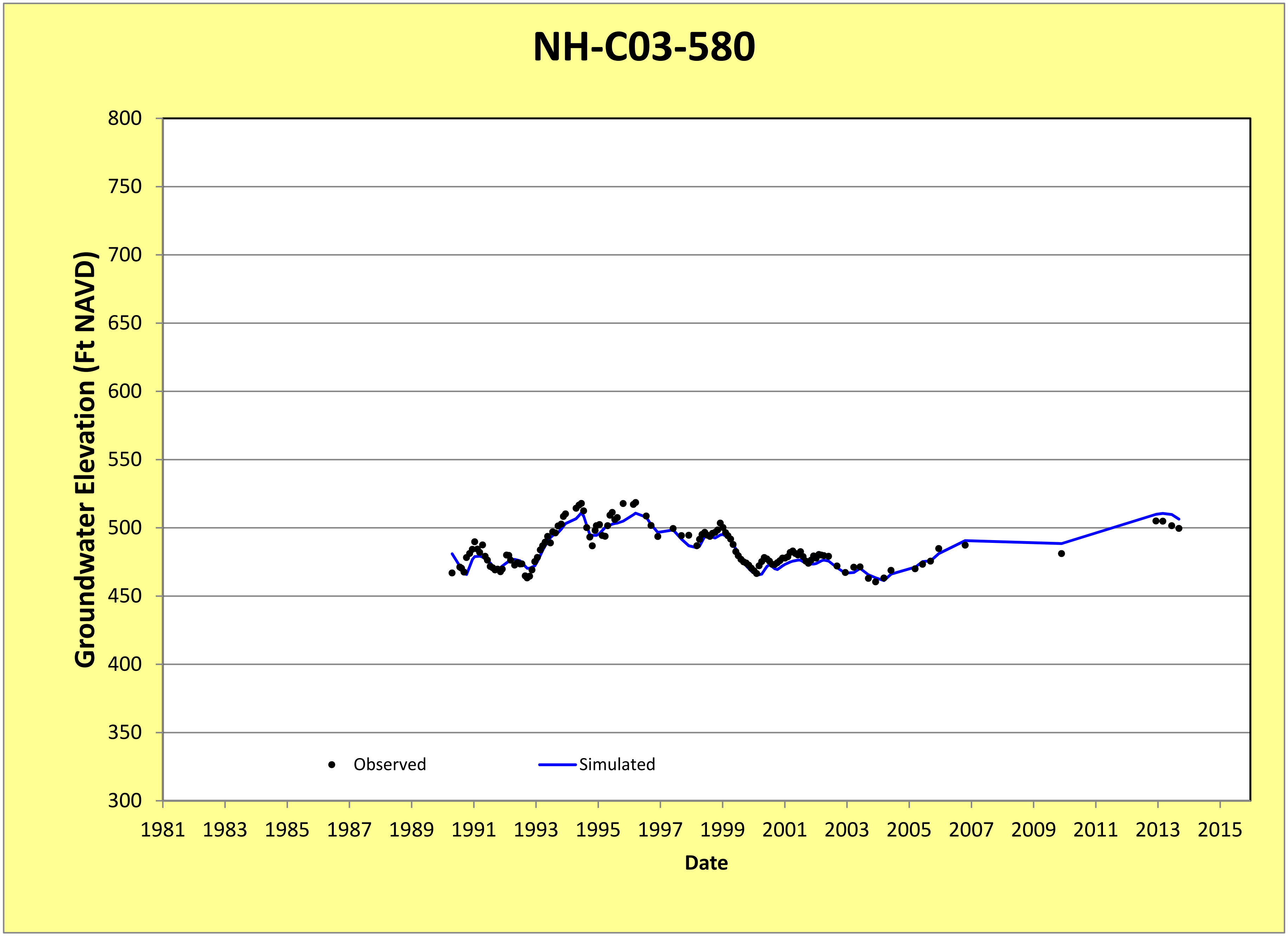
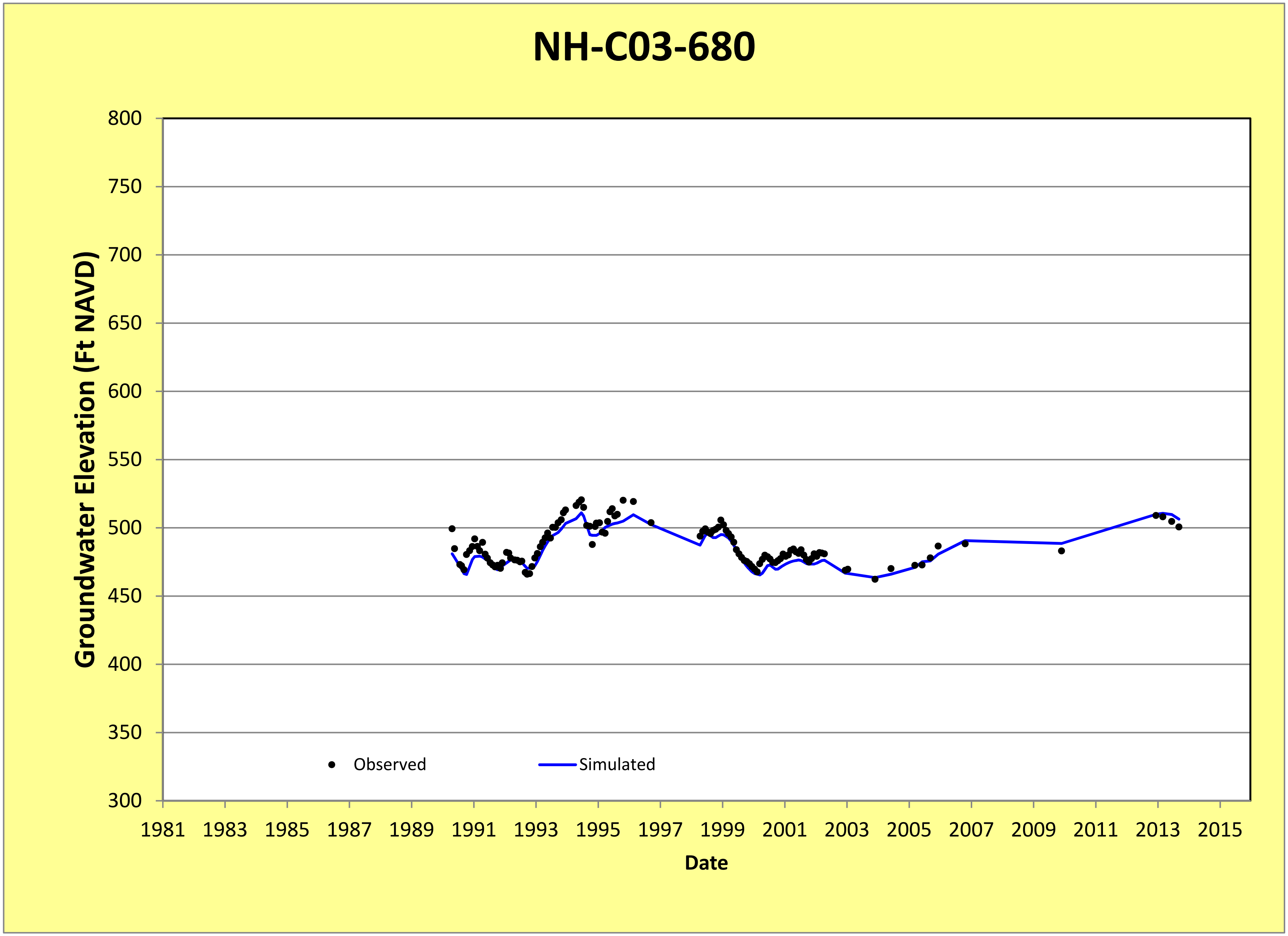
2003
2005
2007
2009
2011
2013
2015
Date

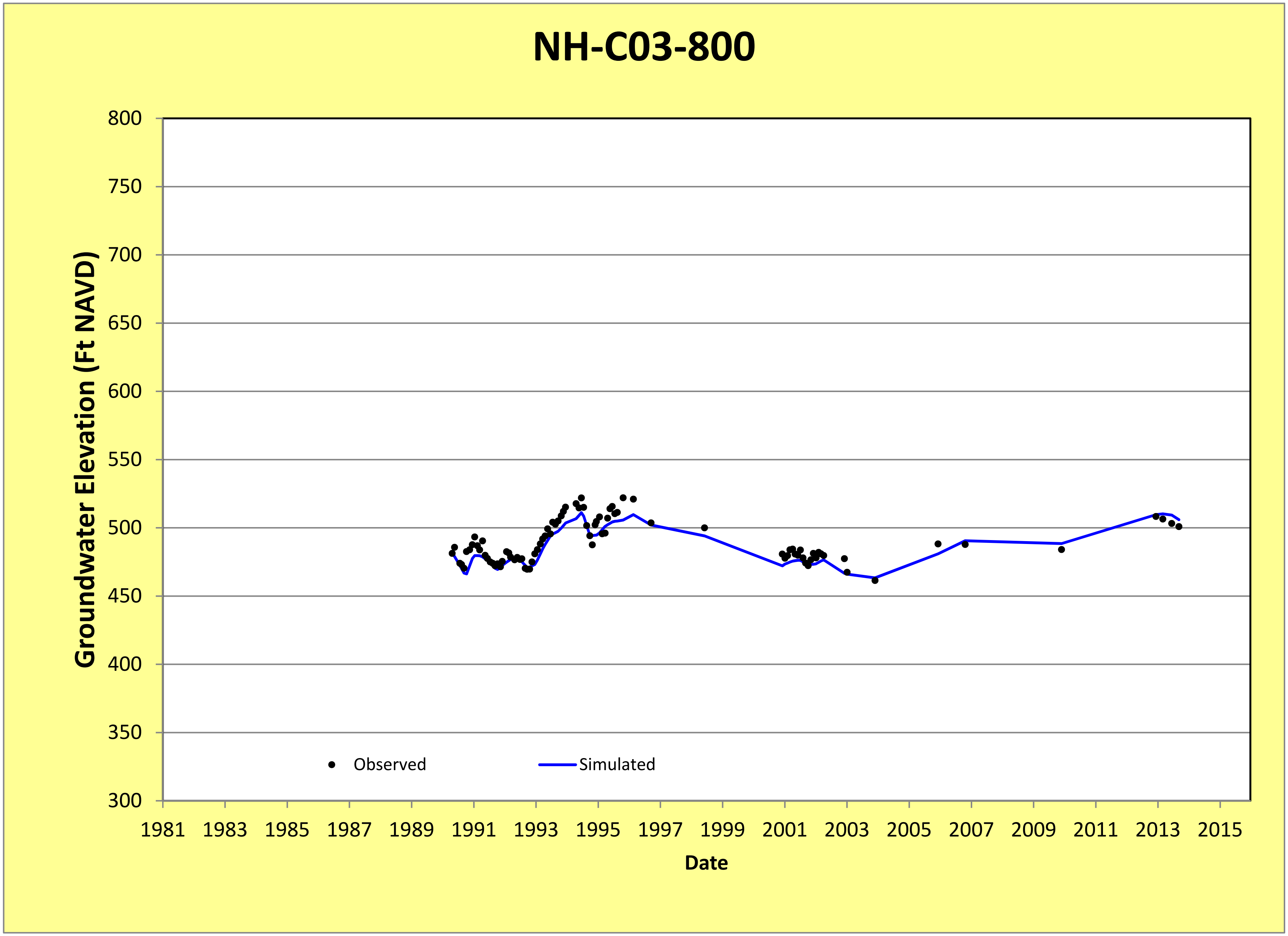


NH-C03-380
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated


NH-C03-580
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated



NH-C03-680
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date



NH-C03-800
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
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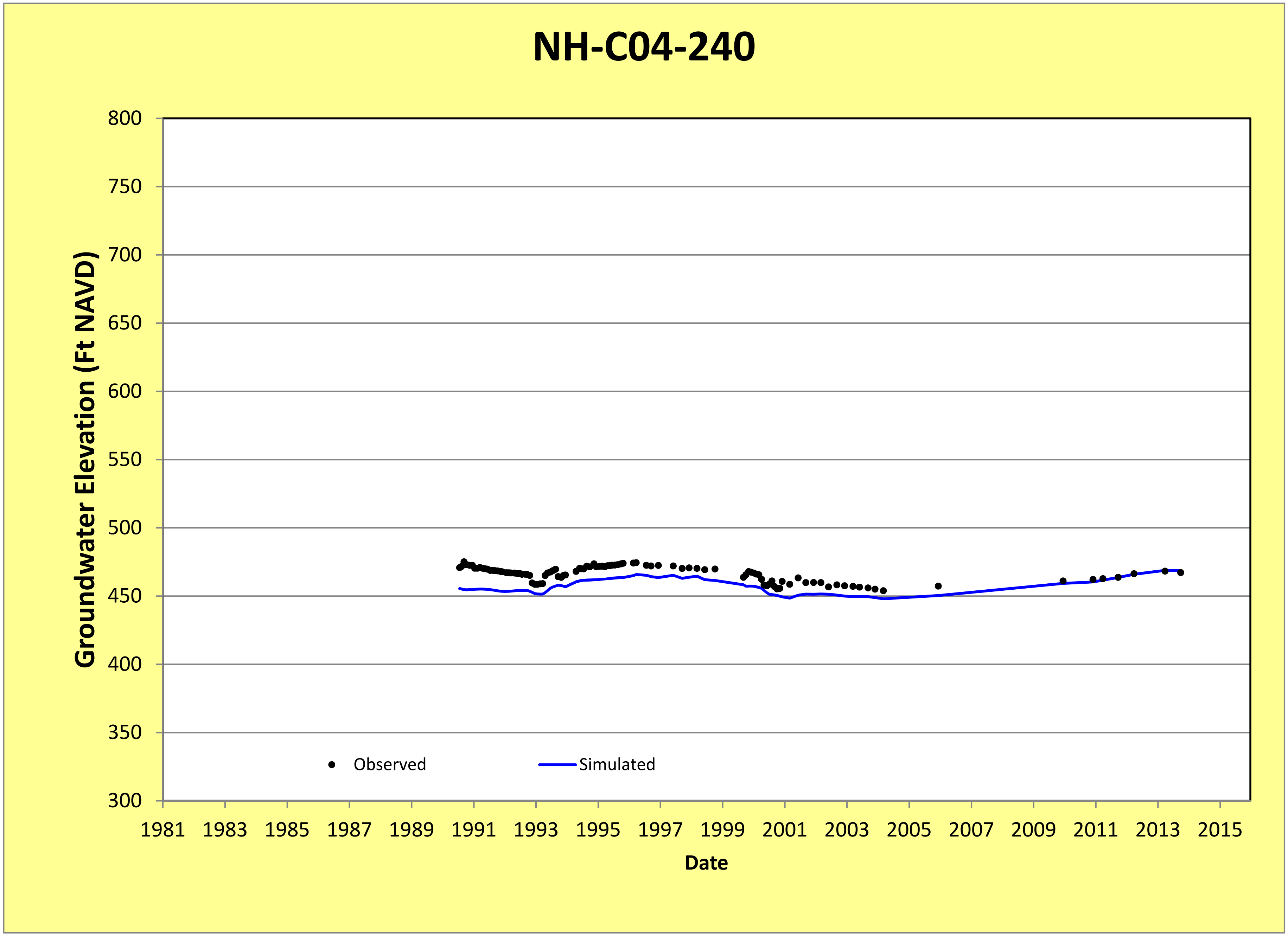
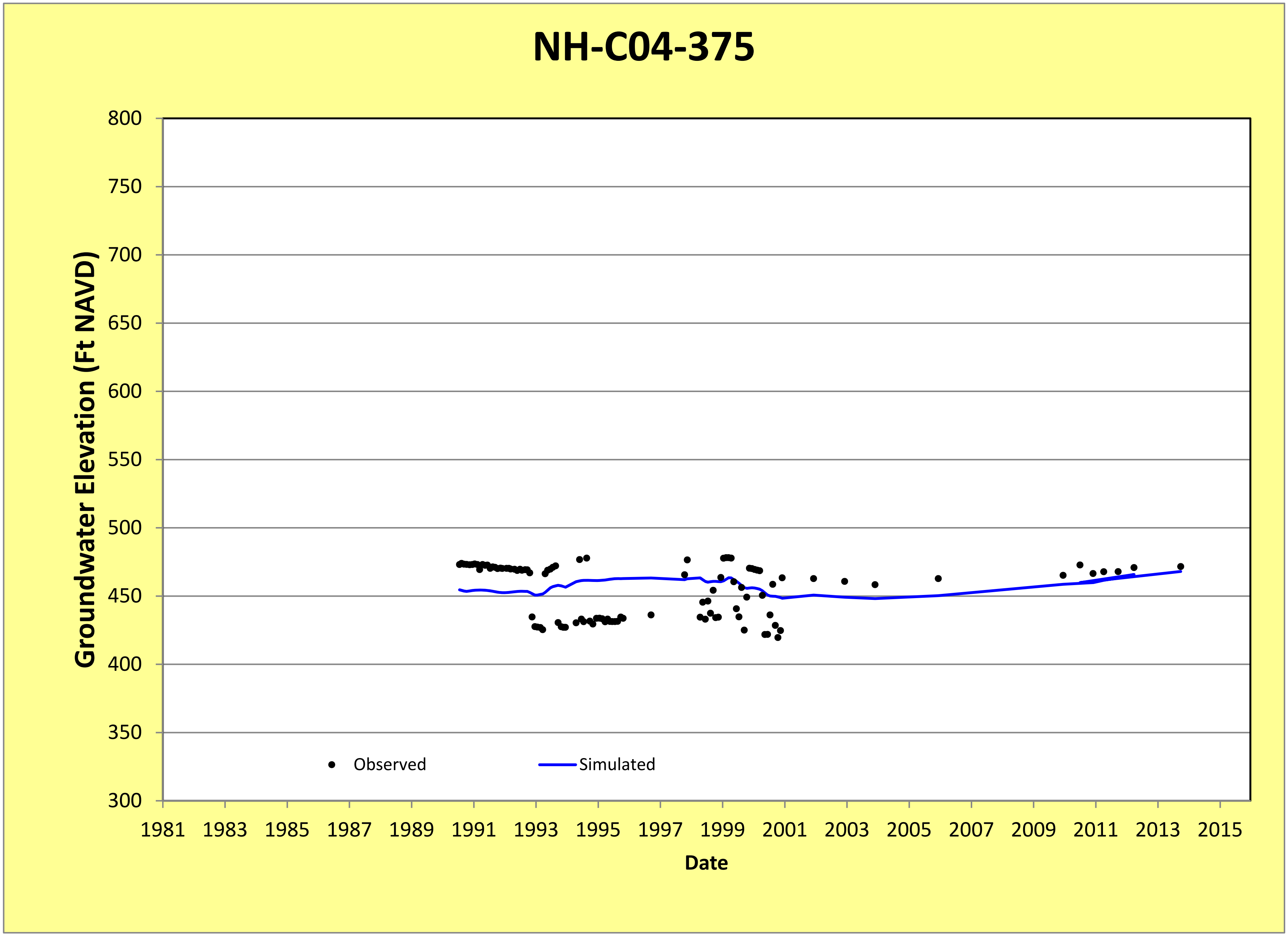
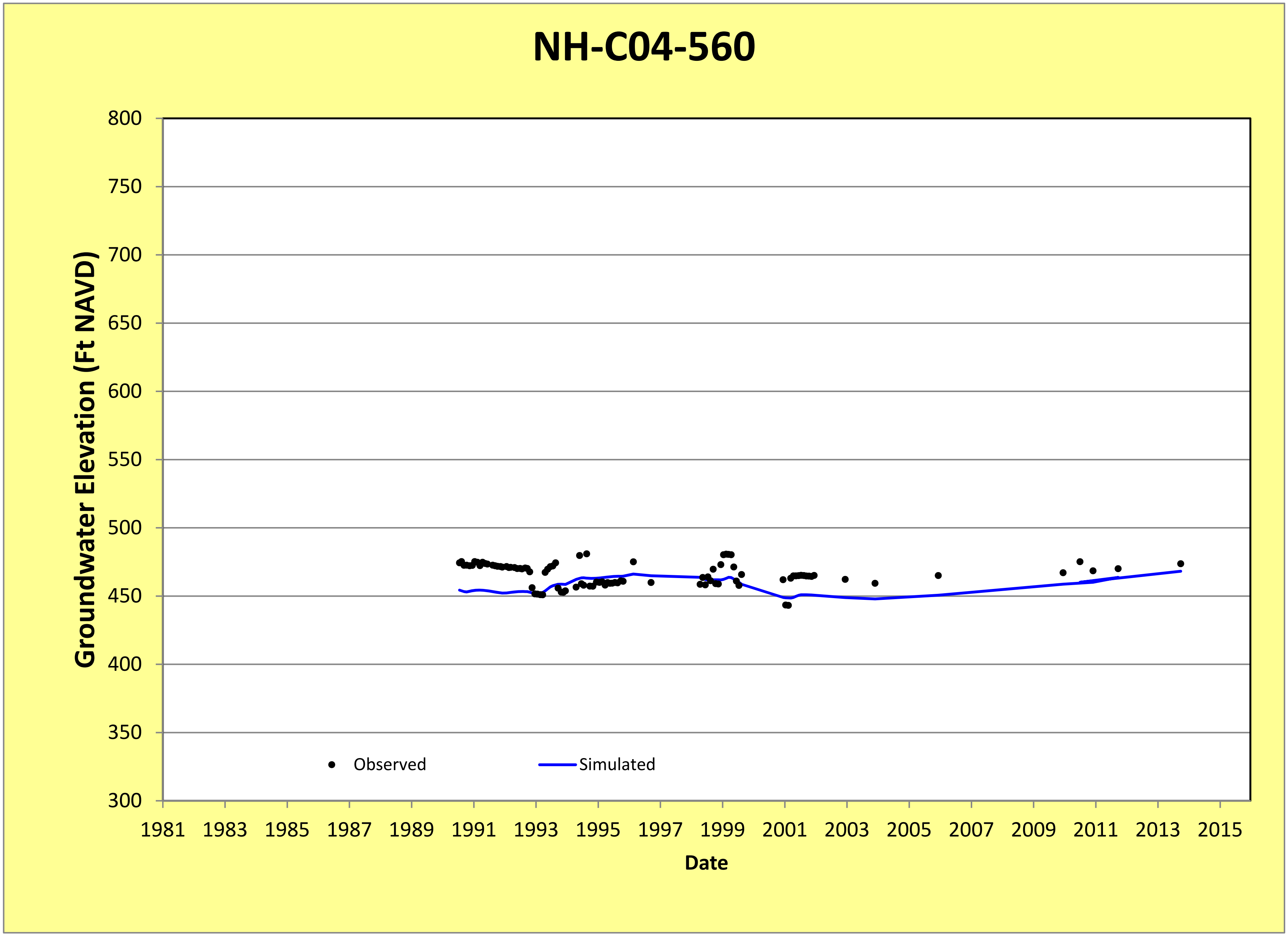
2003
2005
2007
2009
2011
2013
2015
Date


NH-C04-240
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated



NH-C04-375
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated


NH-C04-560
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
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1987
1989
1991
1993
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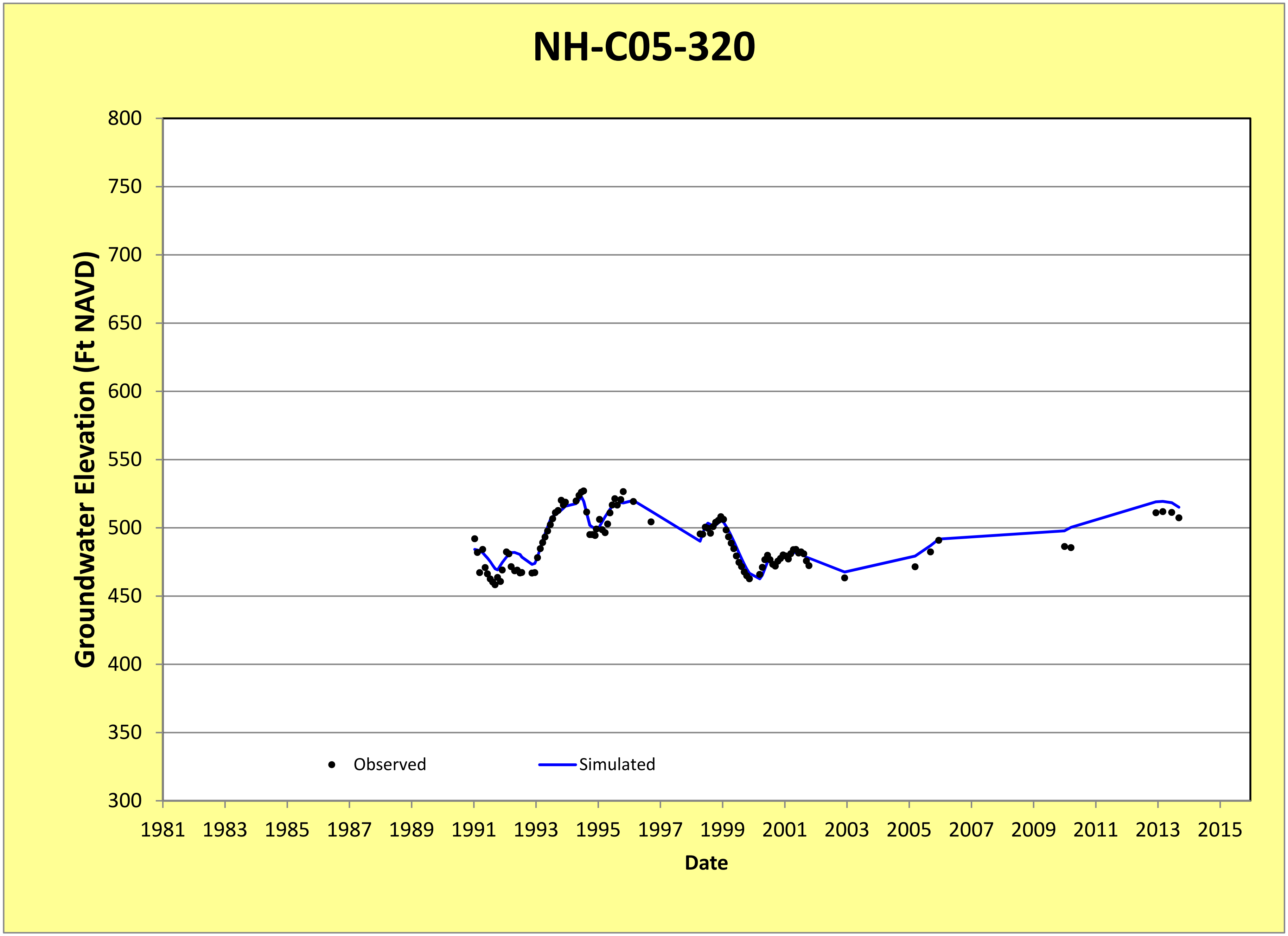
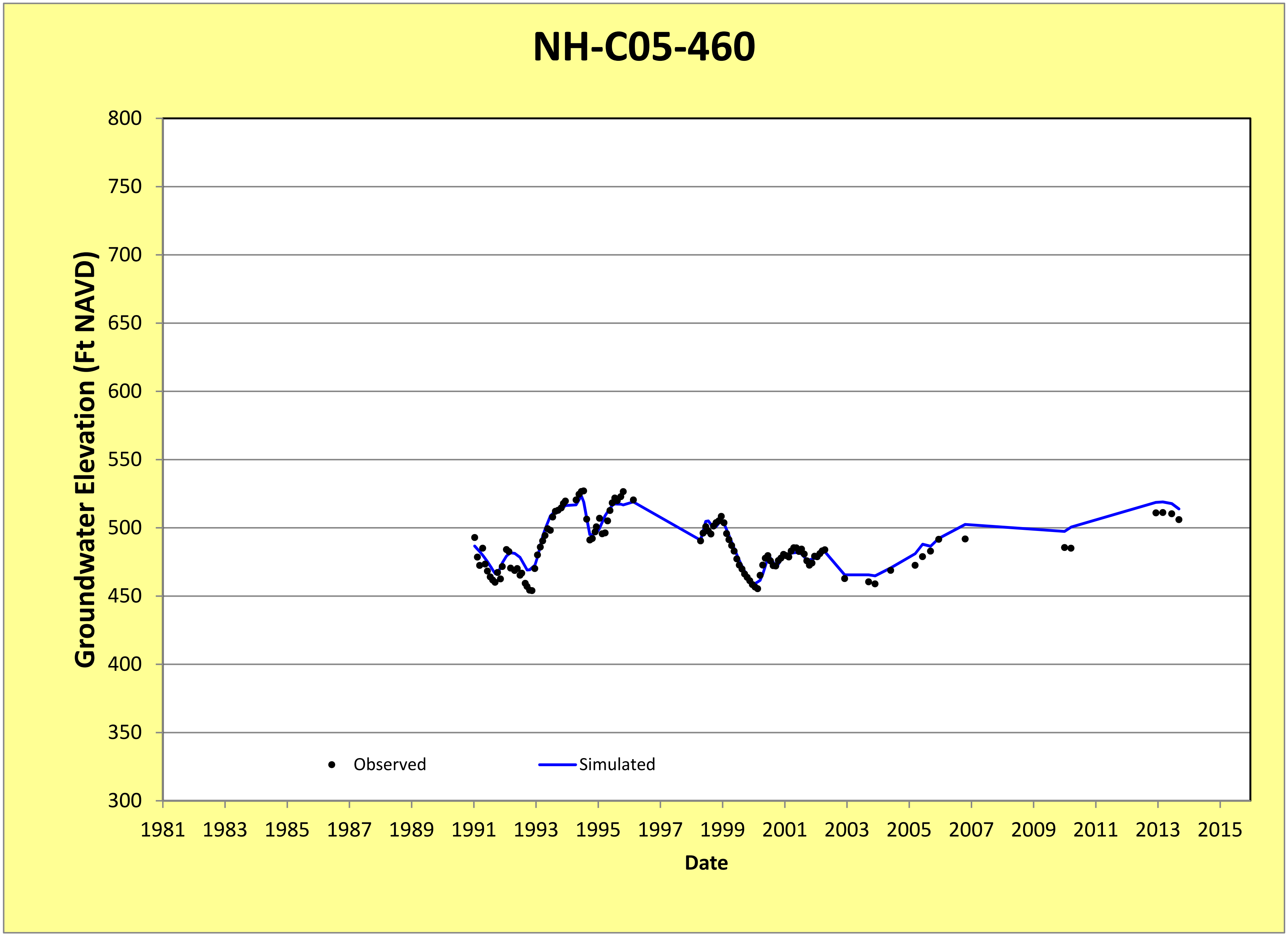
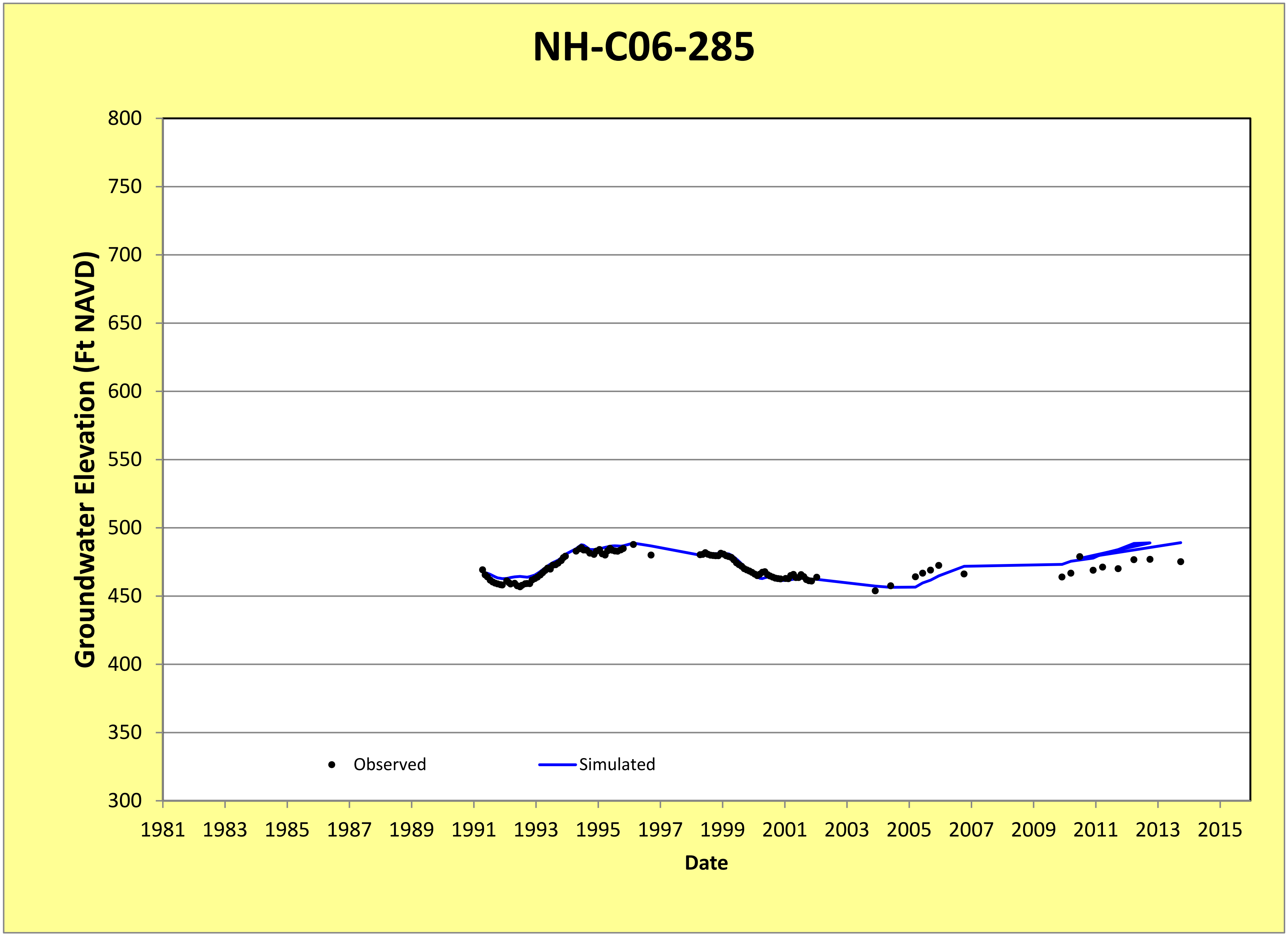
2005
2007
2009
2011
2013
2015
Date



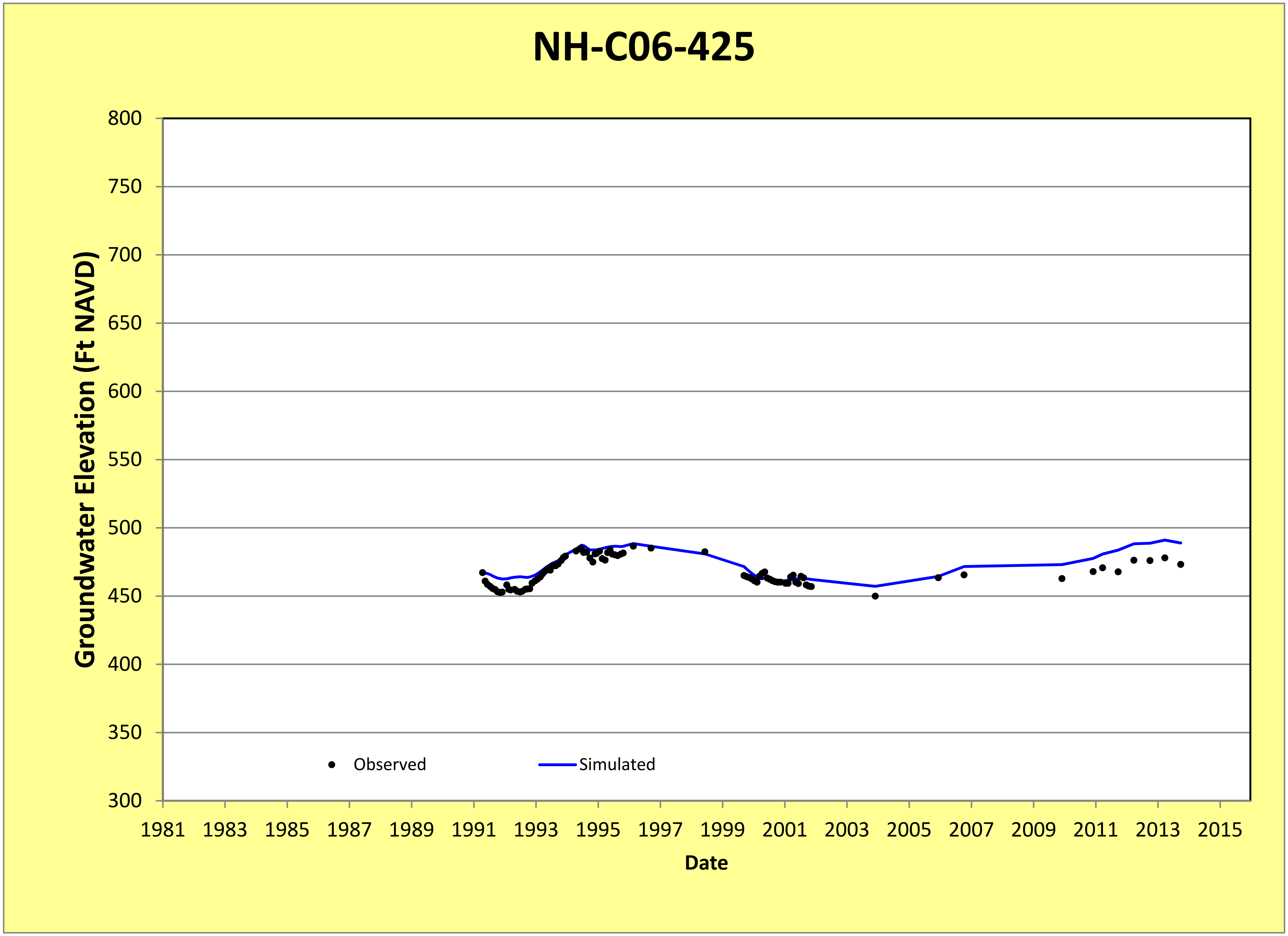
NH-C05-320
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date



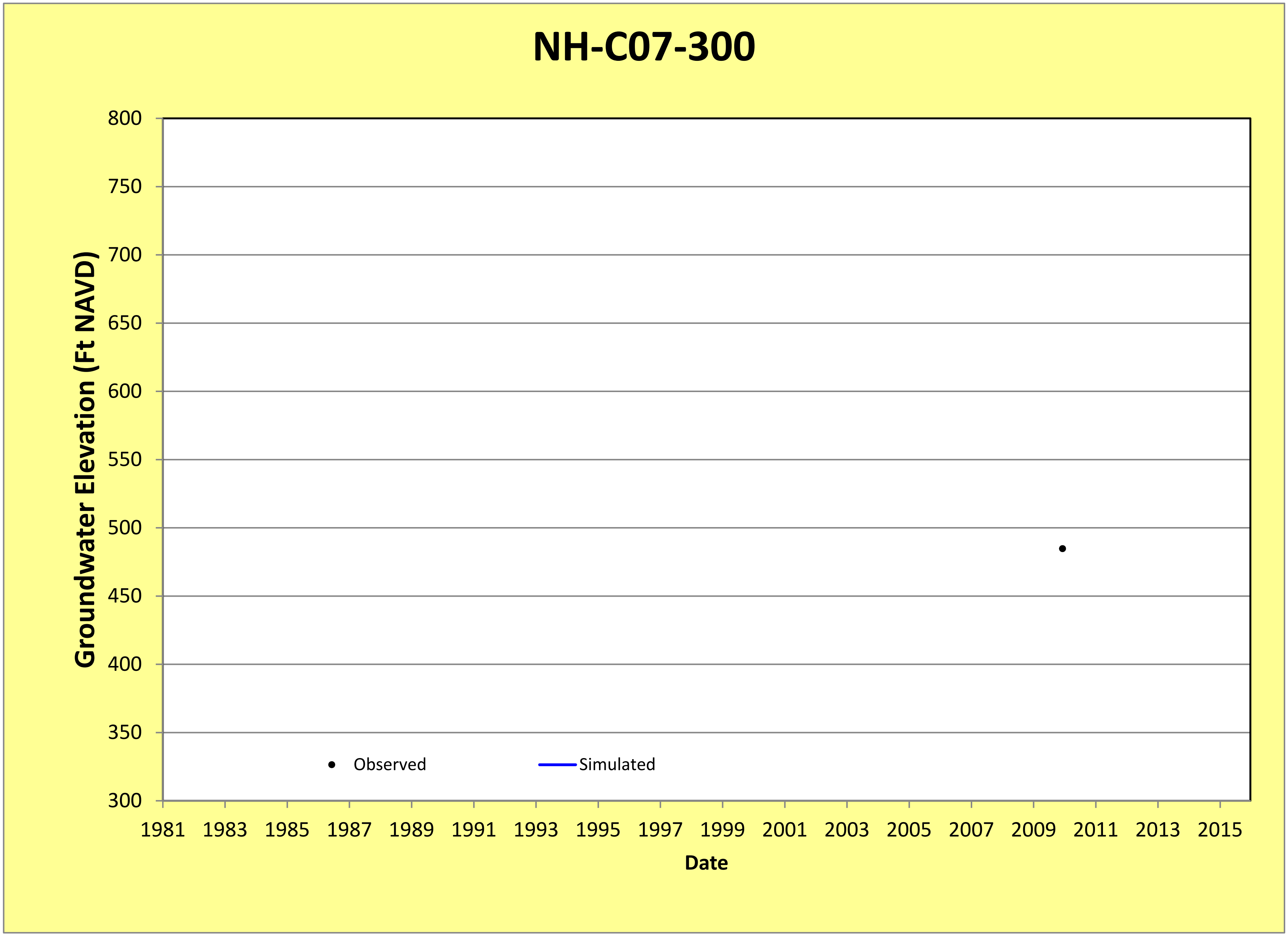
NH-C05-460
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date

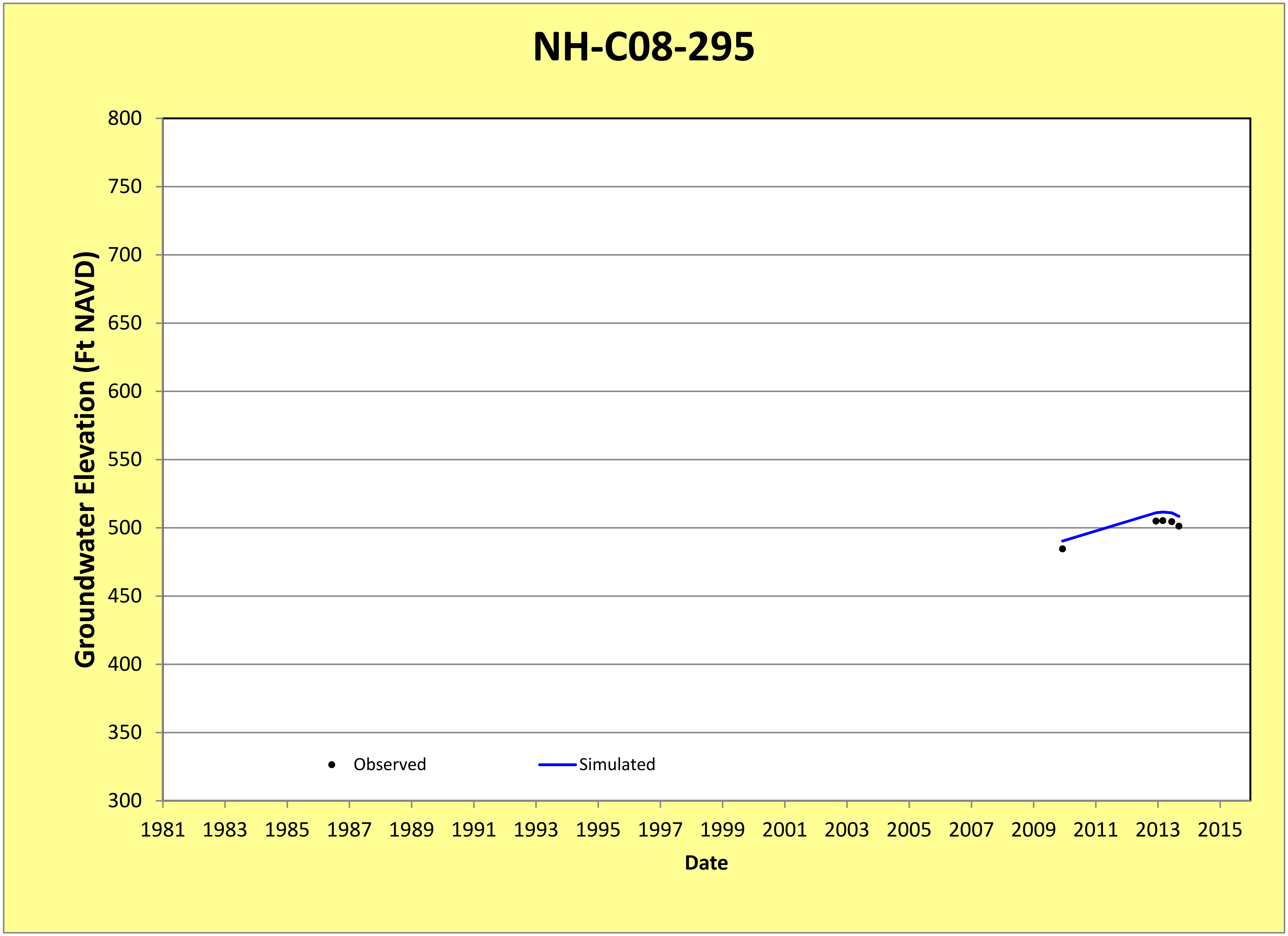


NH-C06-285
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date

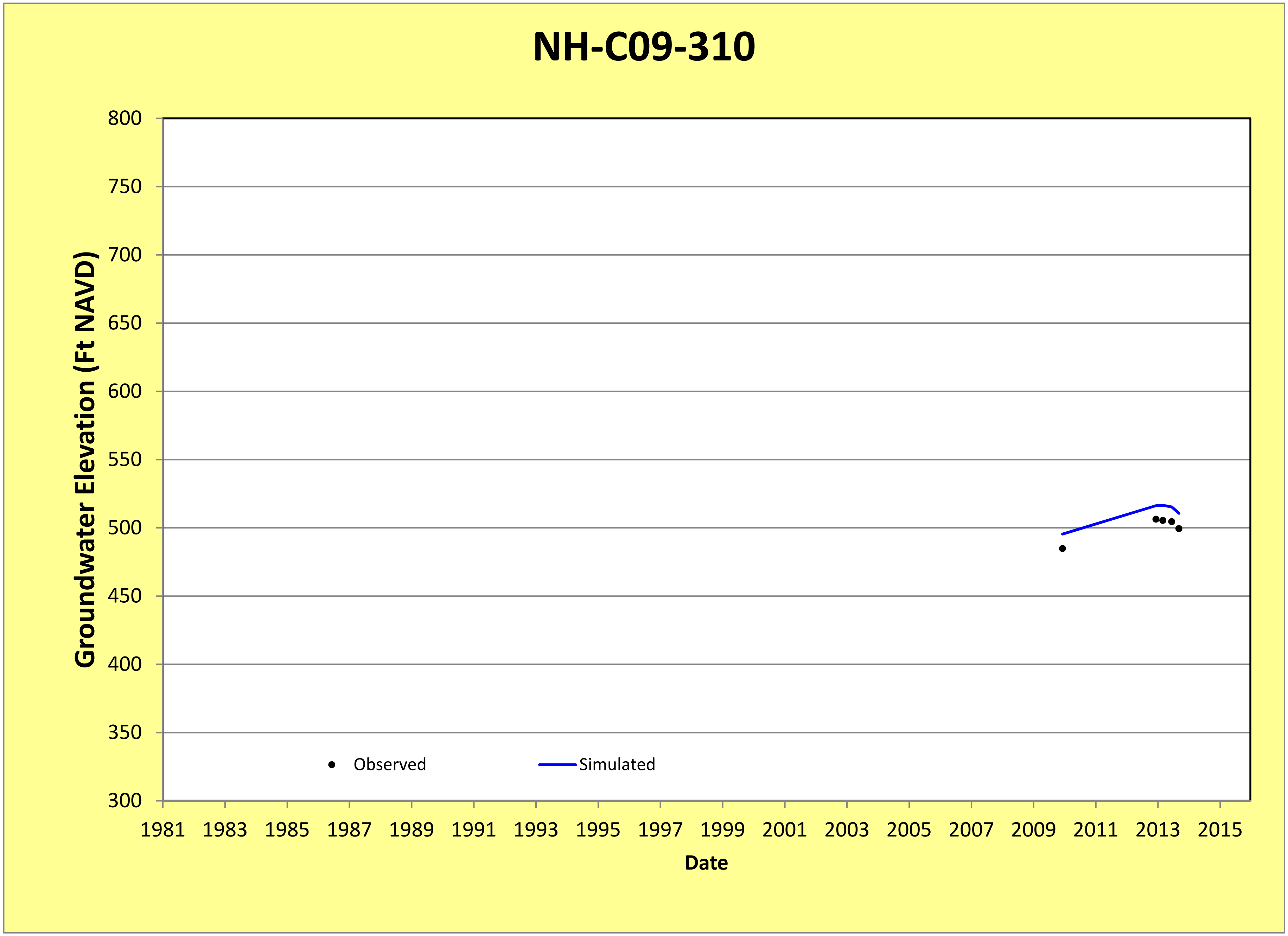


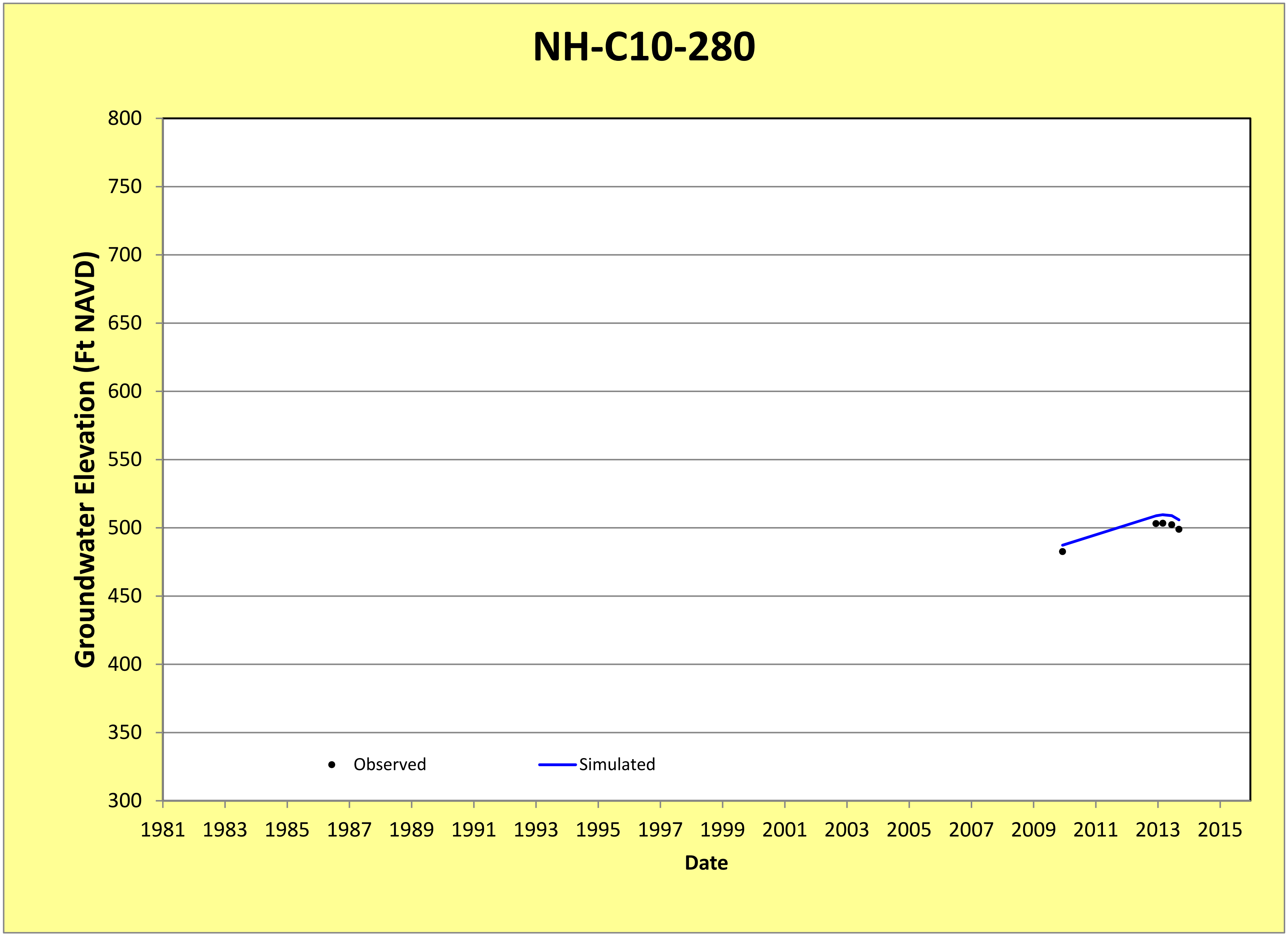
NH-C06-425
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date


NH-C07-300
800
750
700
650
600
550
500
450
400
350
300
Groundwater Elevation (Ft NAVD)
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date

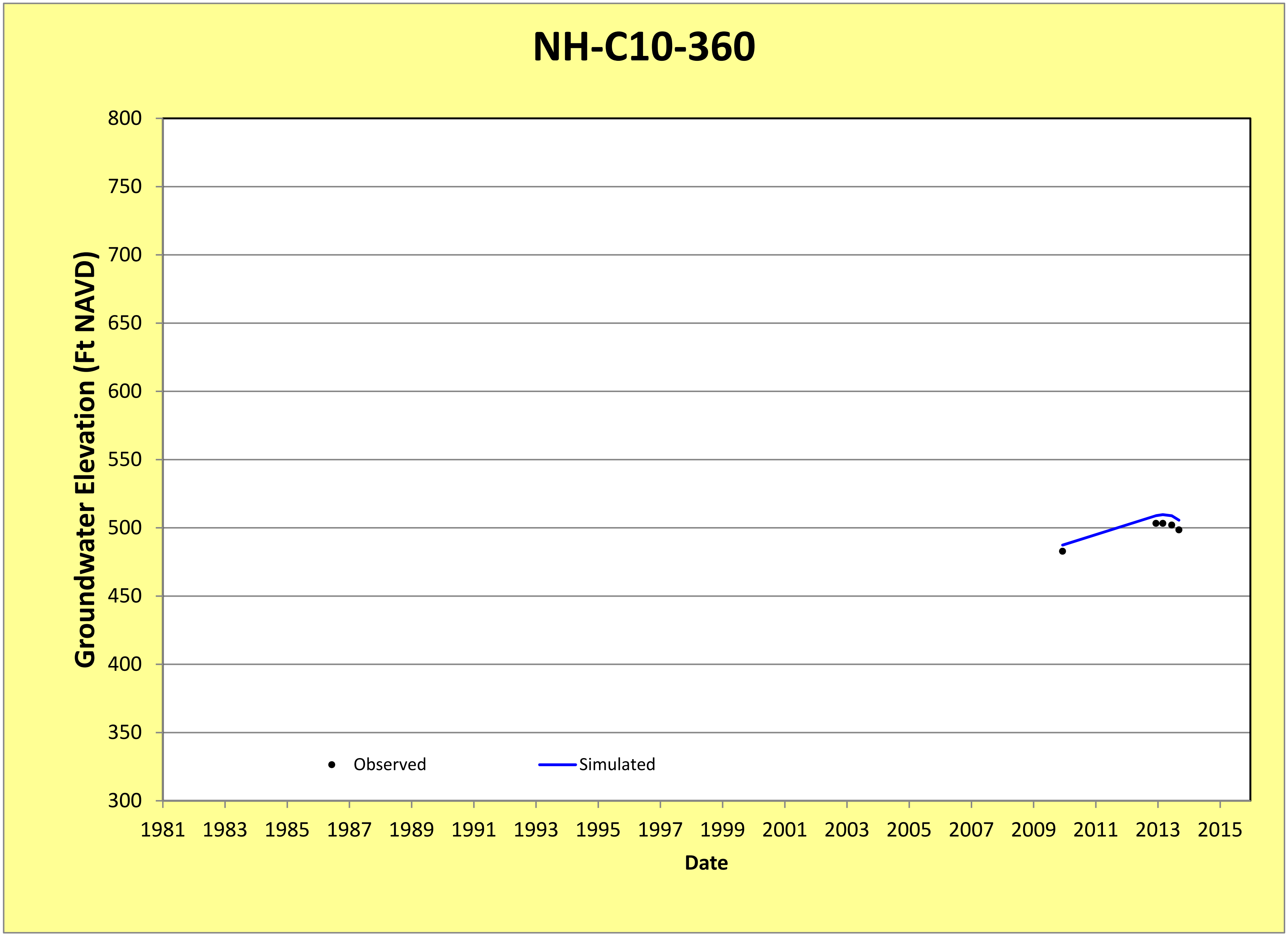


NH-C08-295
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated

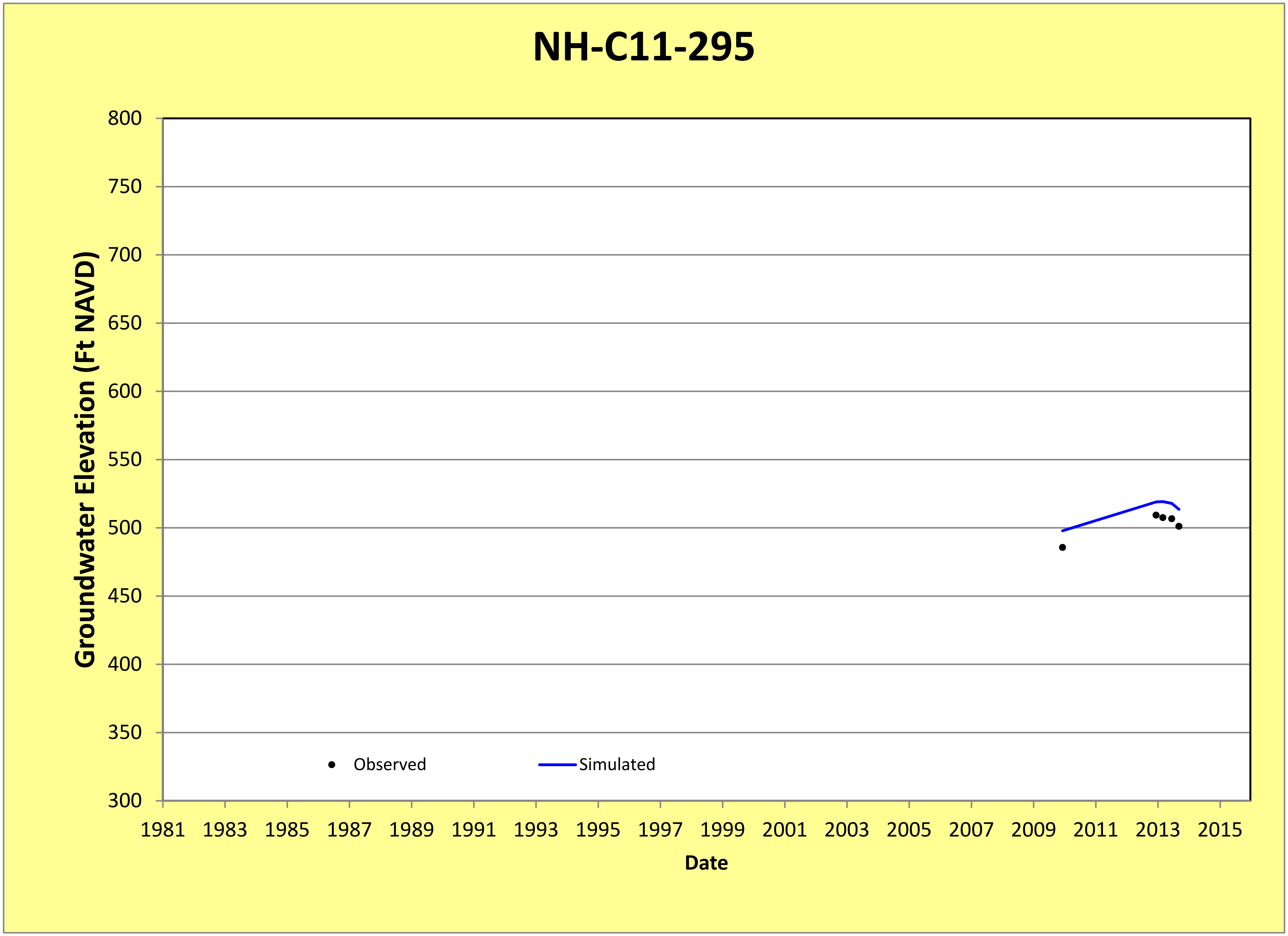

NH-C09-310
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date

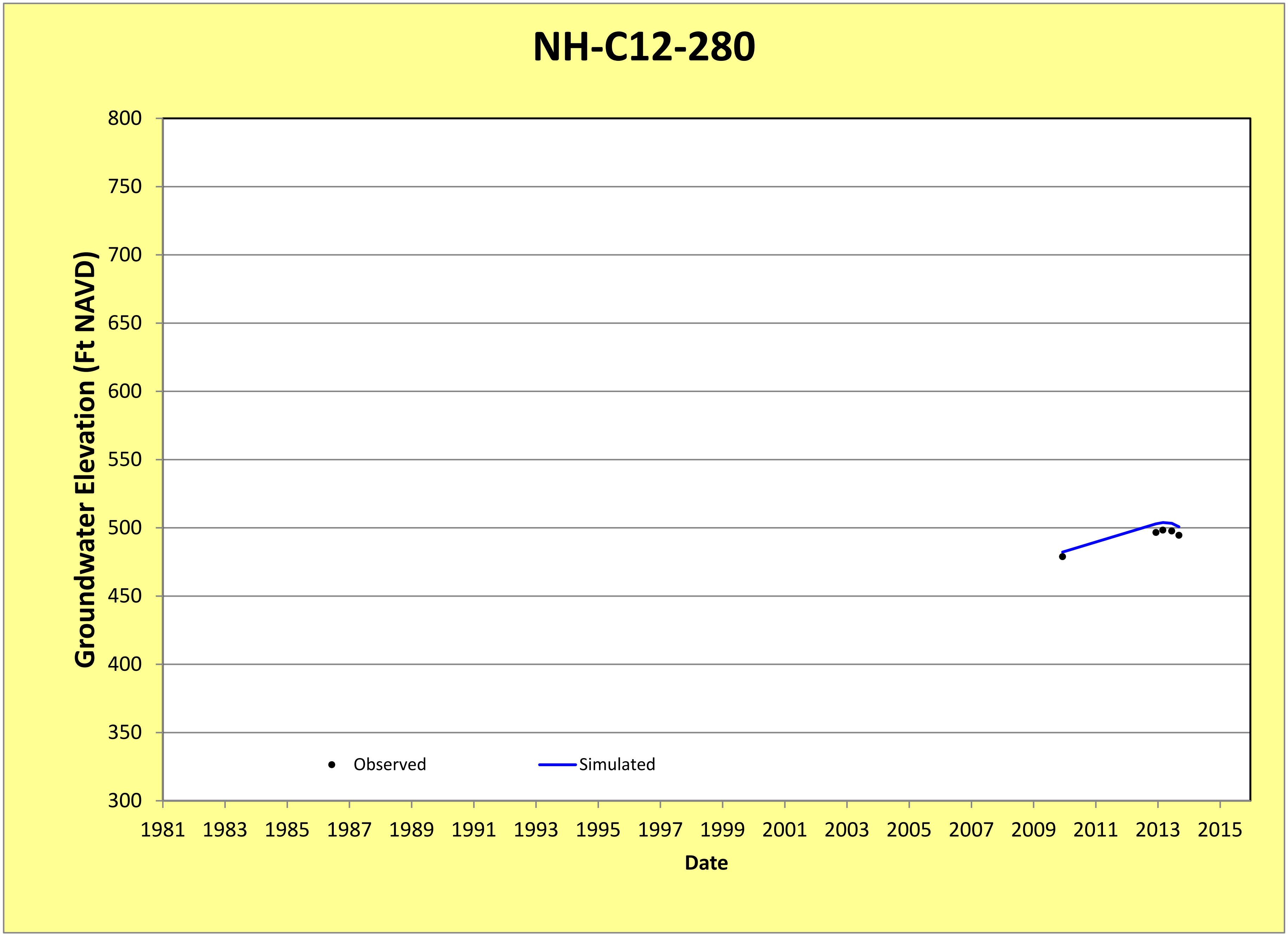


NH-C10-280
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated

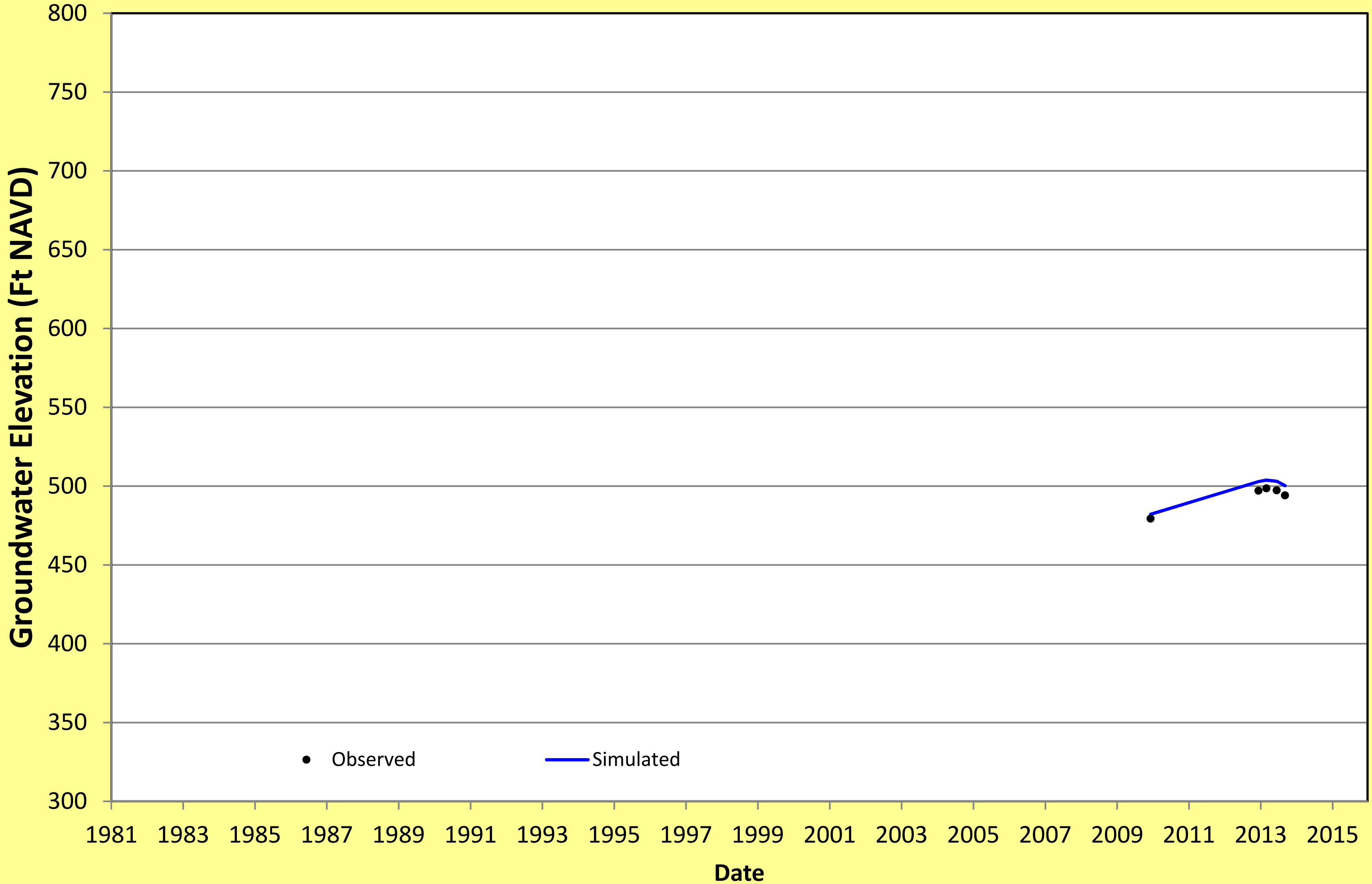


NH-C10-360
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date

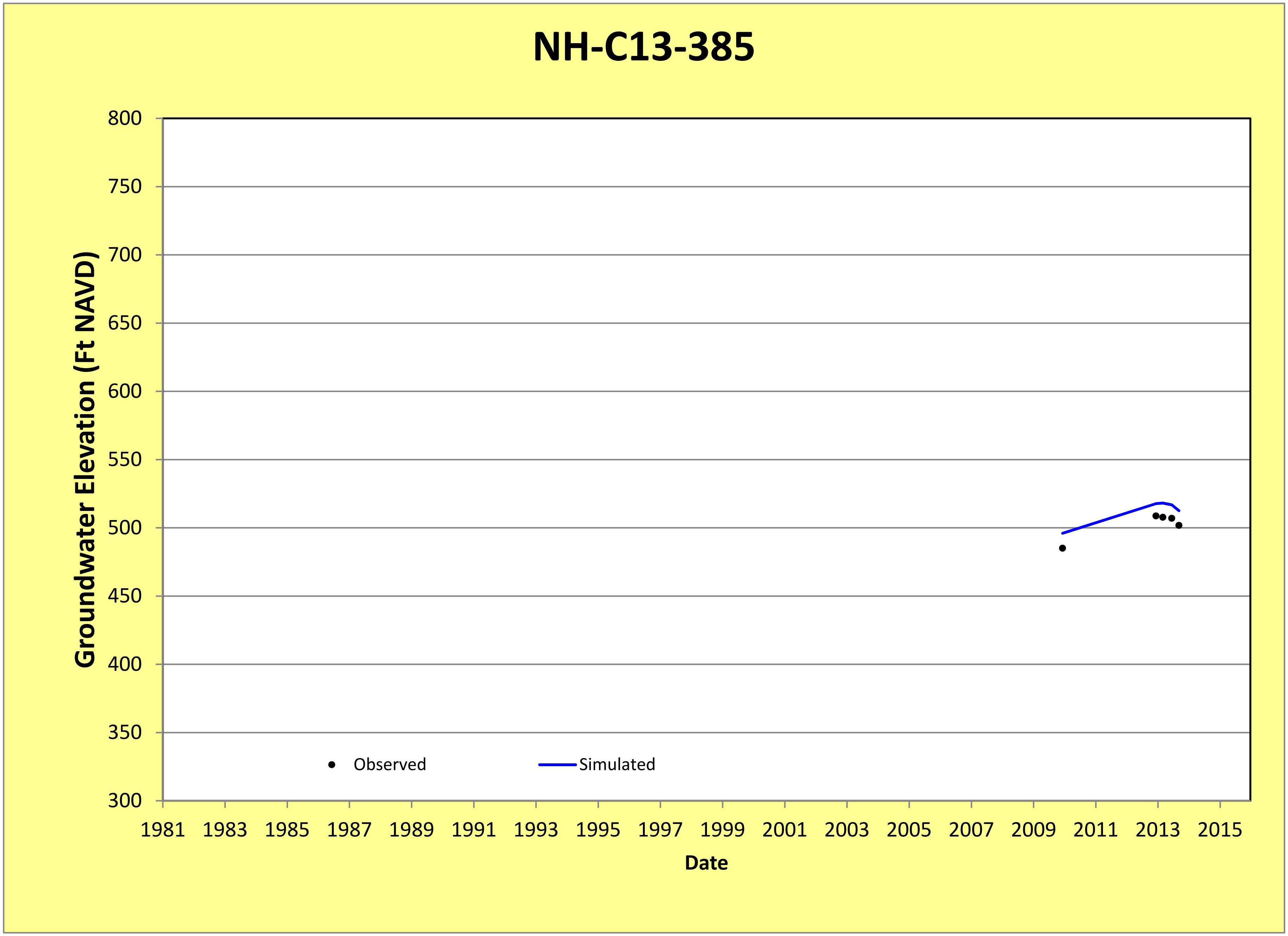

NH-C11-295
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated

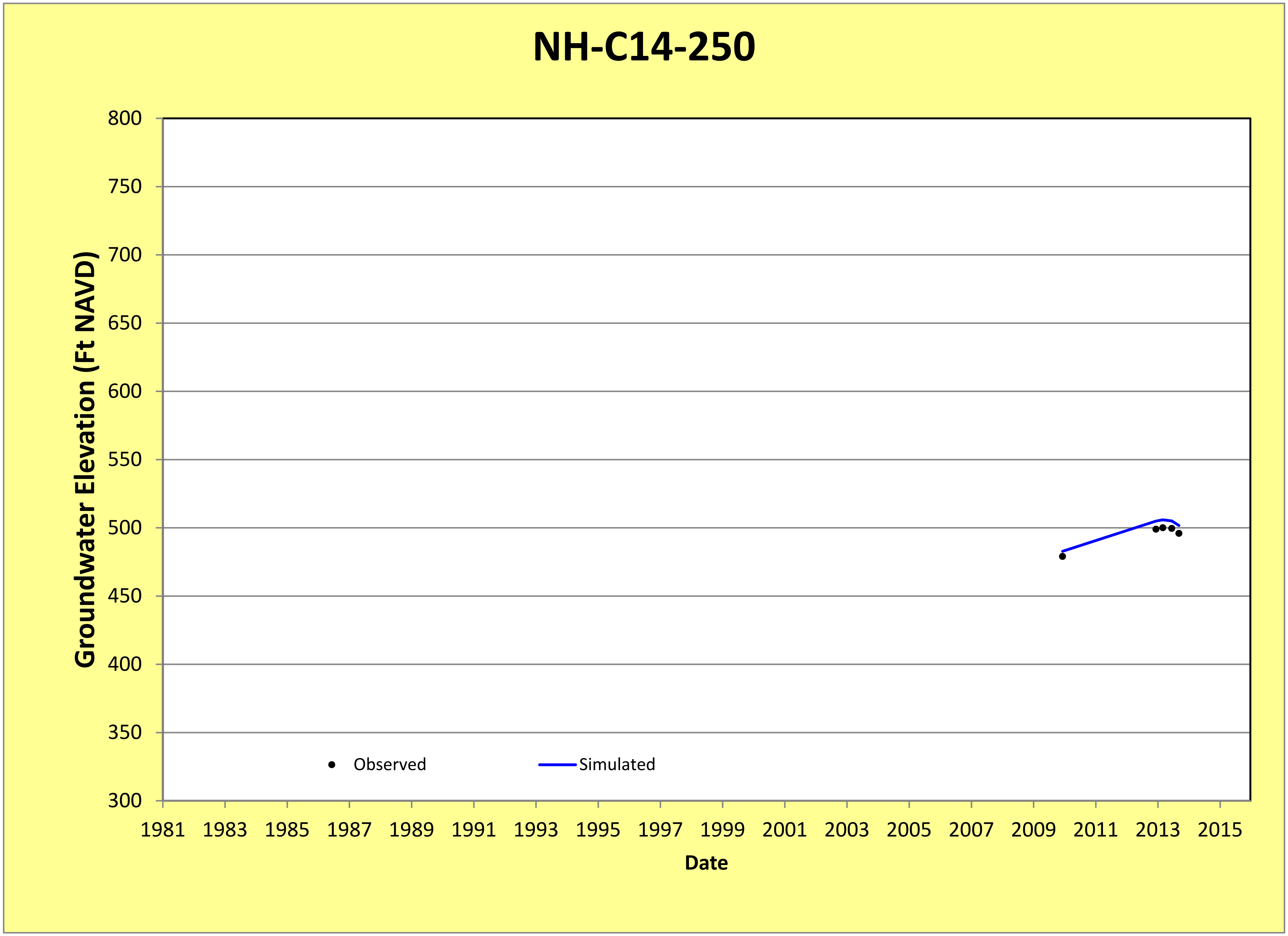

NH-C12-280
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated

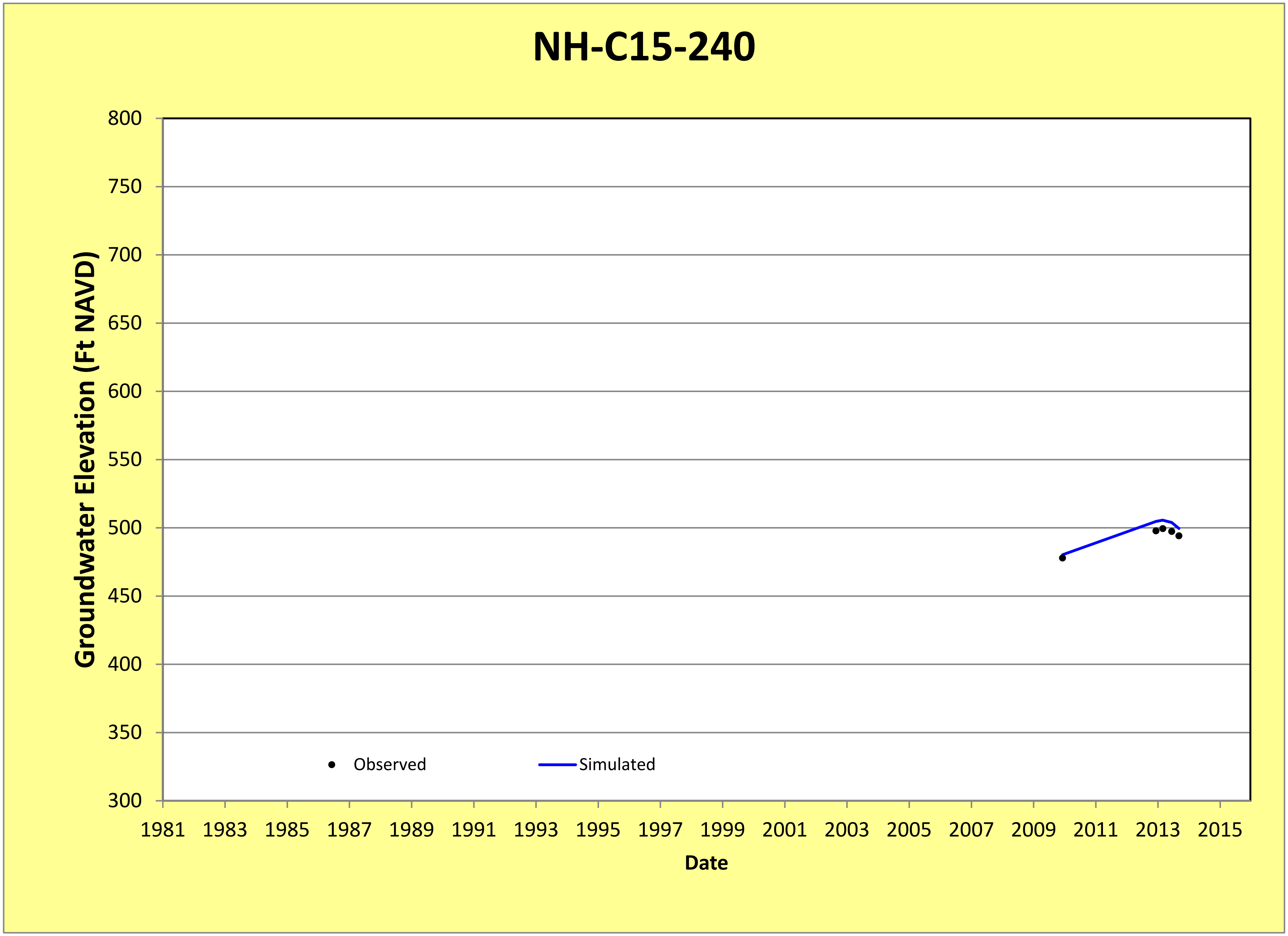
NH-C12-360



Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date


NH-C13-385
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date


NH-C14-250
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Date
Observed
Simulated


NH-C15-240
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
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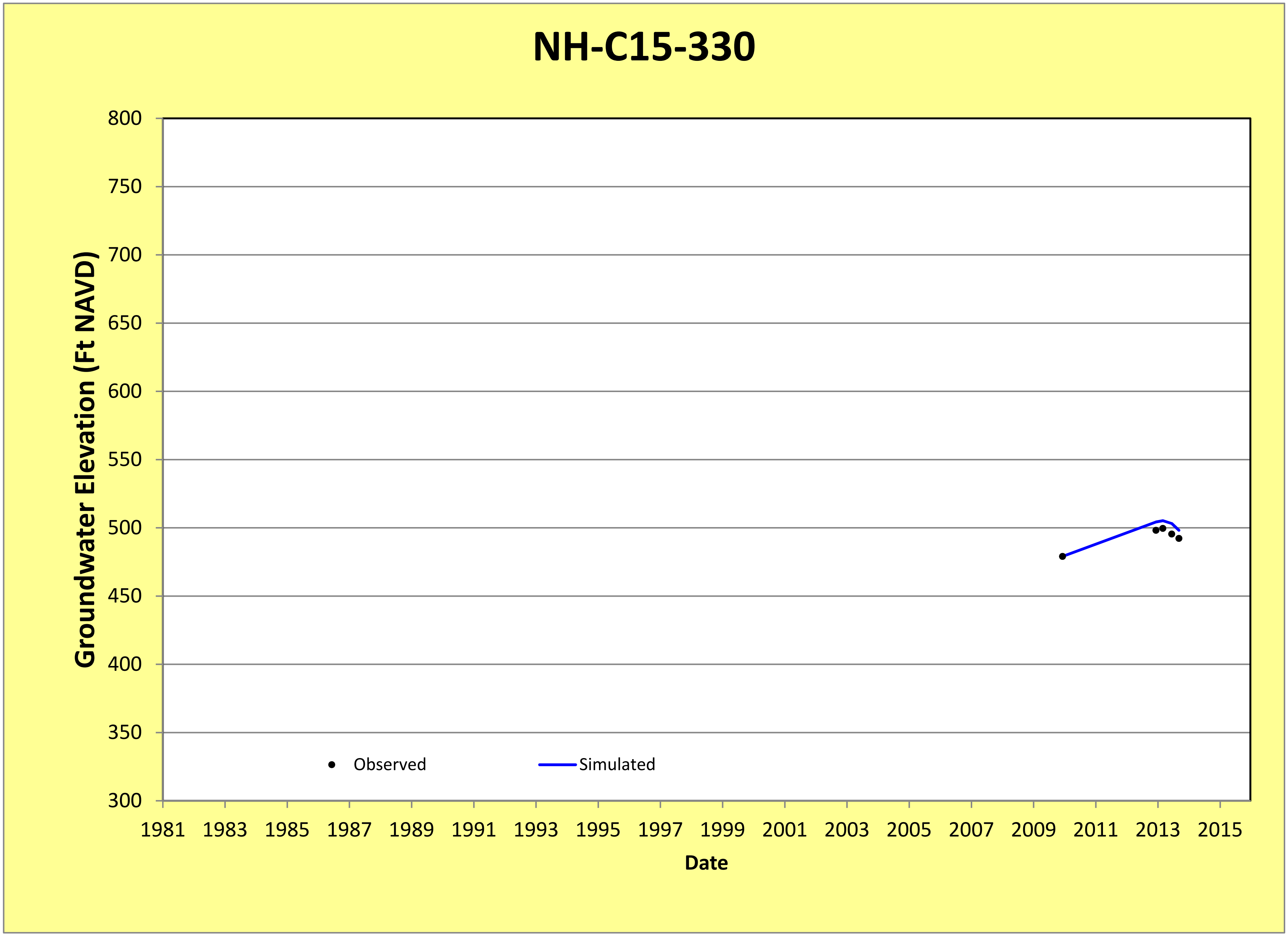
2015
Date
Observed
Simulated


NH-C15-330
Groundwater Elevation (Ft NAVD)
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750
700
650
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550
500
450
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350
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Observed
Simulated
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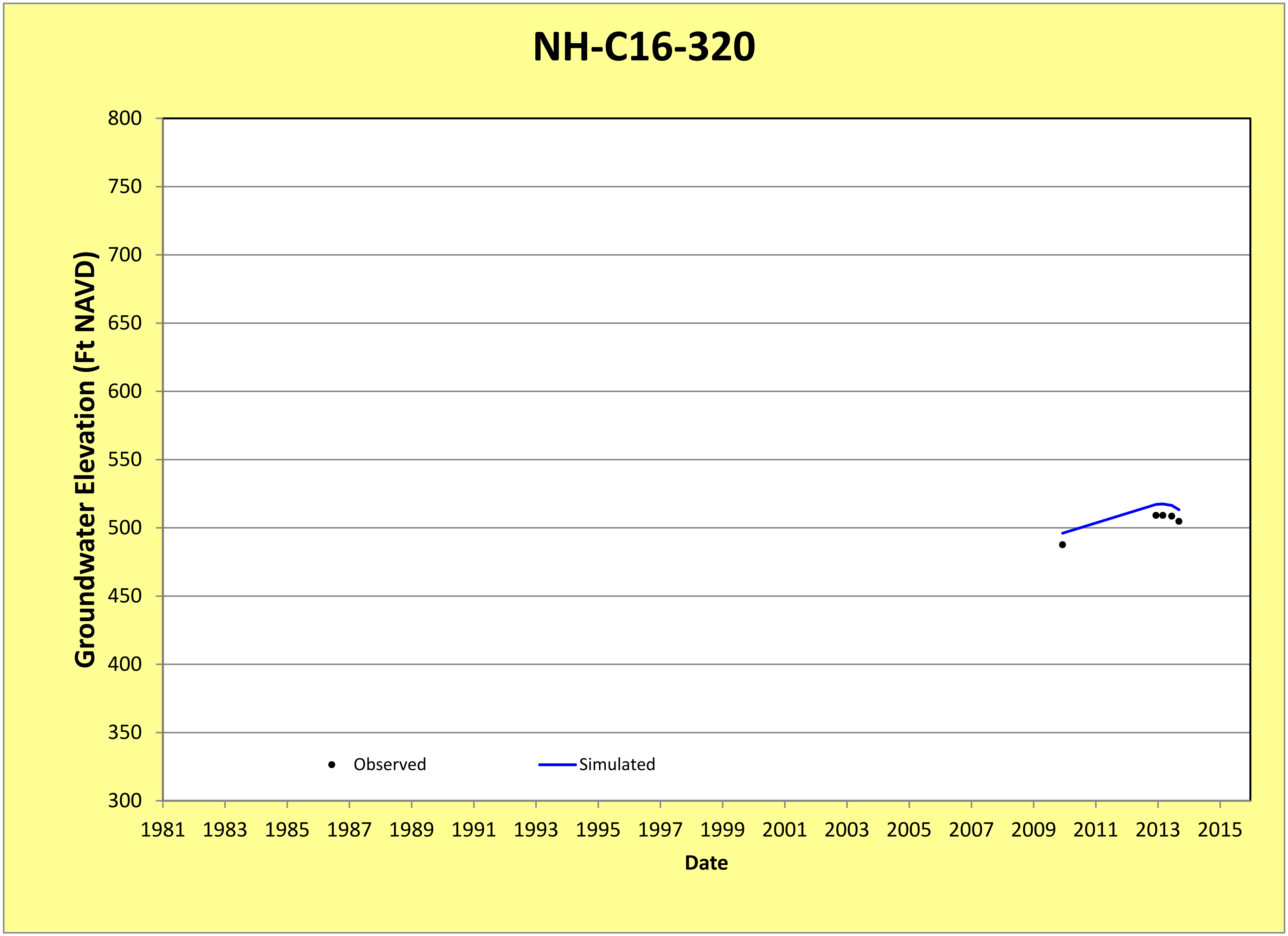
2015
Date


NH-C16-320
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
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Observed
Simulated
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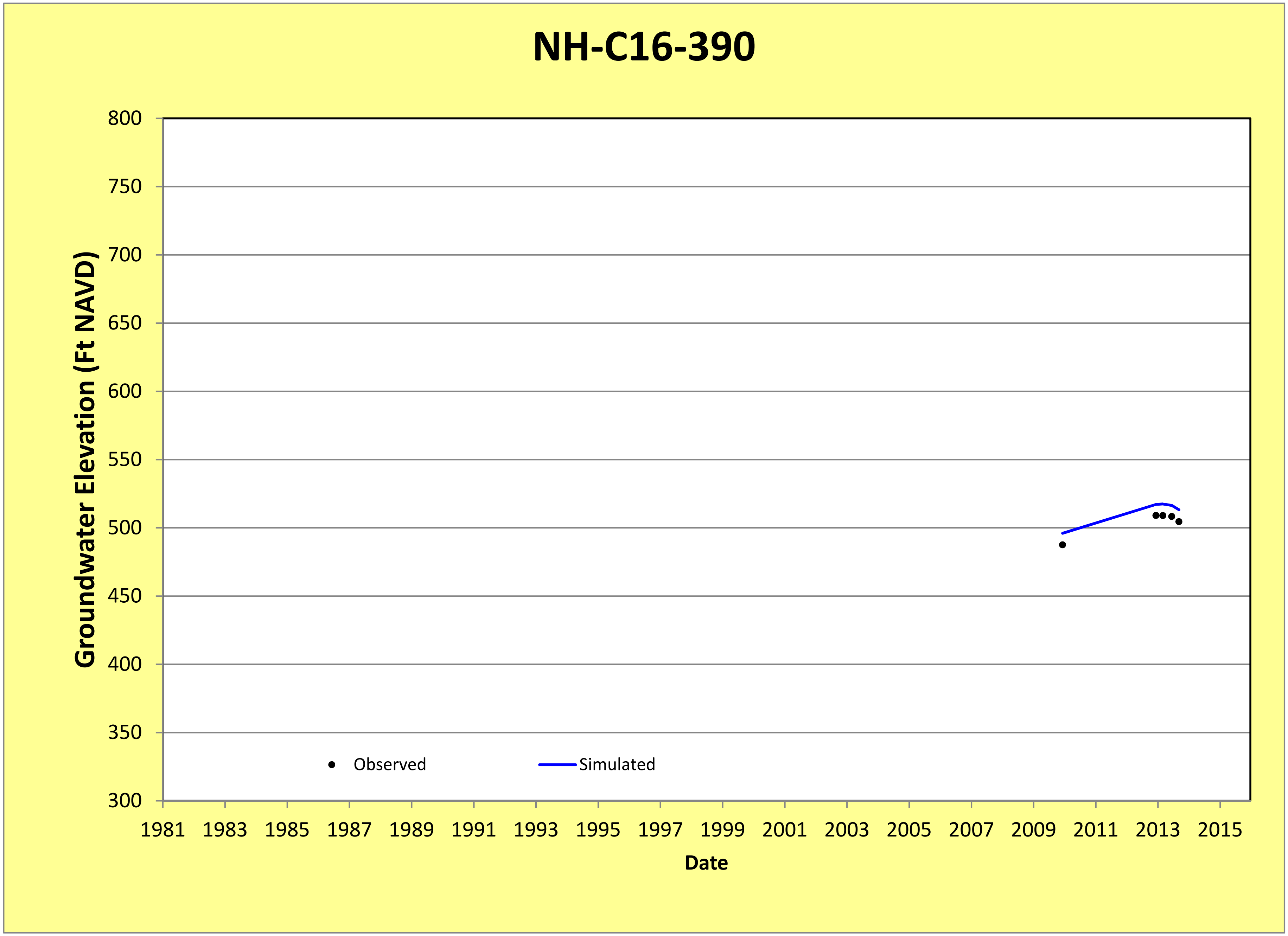

NH-C16-390
Groundwater Elevation (Ft NAVD)
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750
700
650
600
550
500
450
400
350
300
Observed
Simulated
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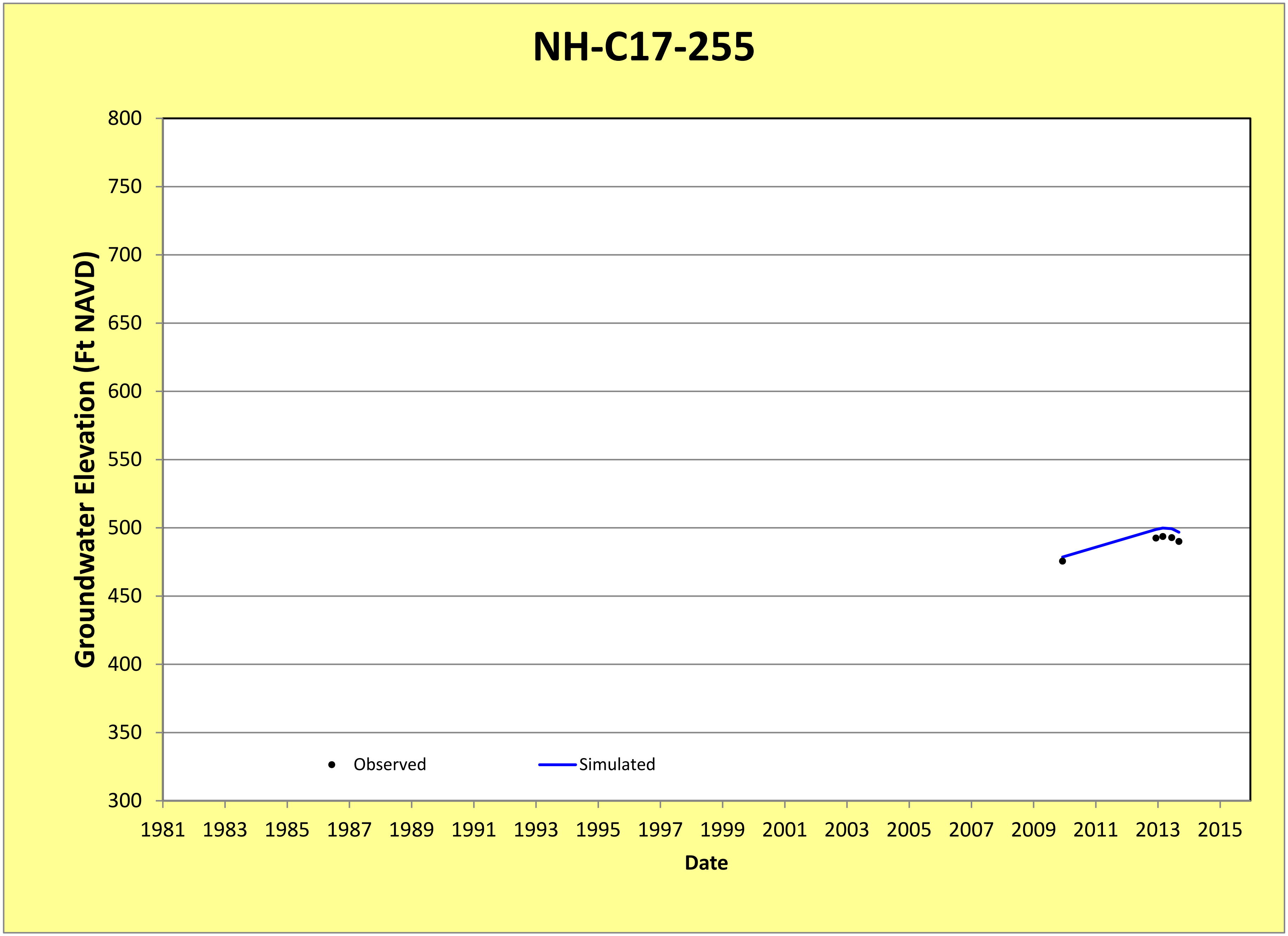
2015
Date


NH-C17-255
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
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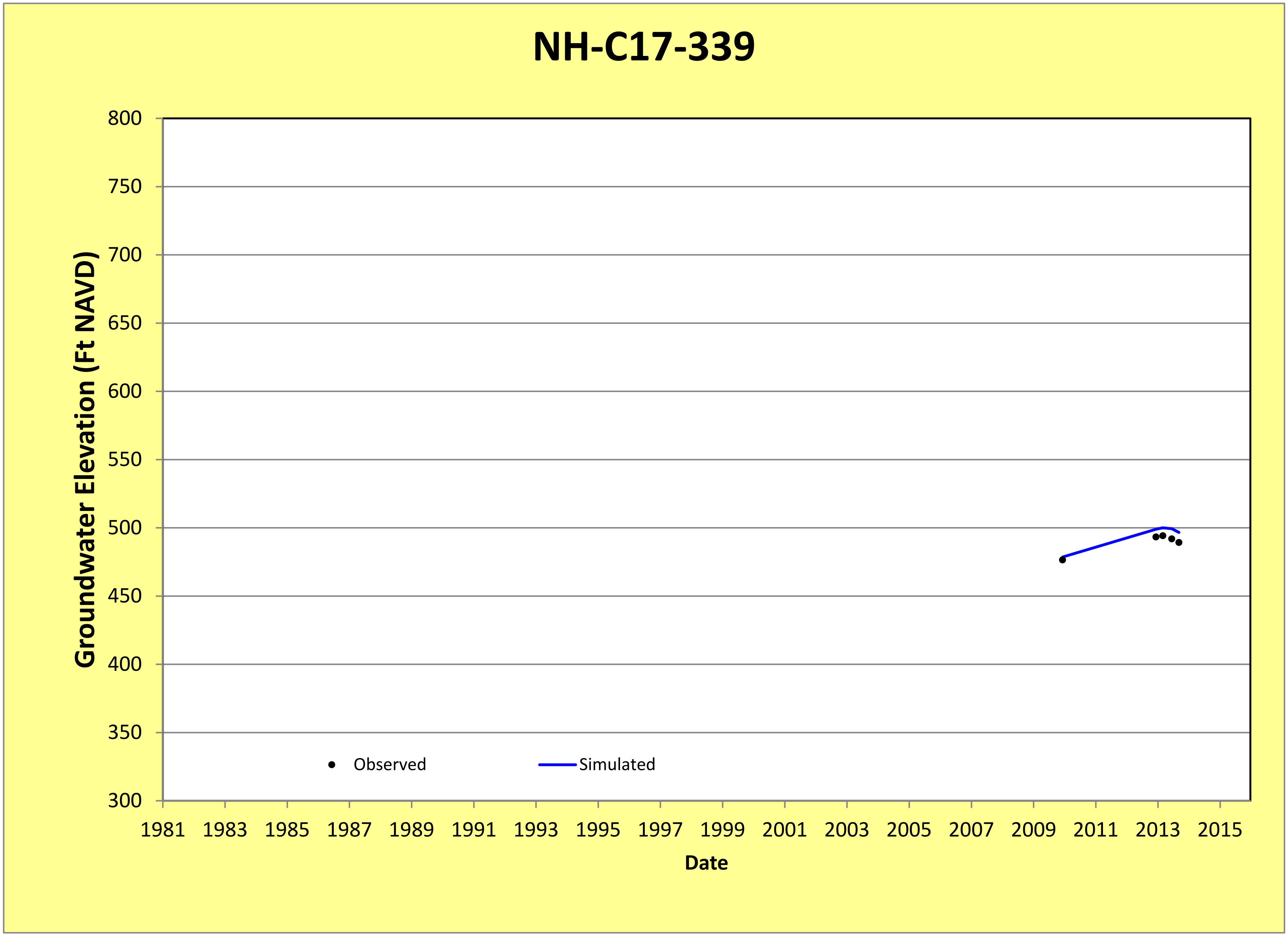
2013
2015
Date


NH-C17-339
800
750
700
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600
550
500
450
400
350
300
Groundwater Elevation (Ft NAVD)
1981
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1995
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2007
2009
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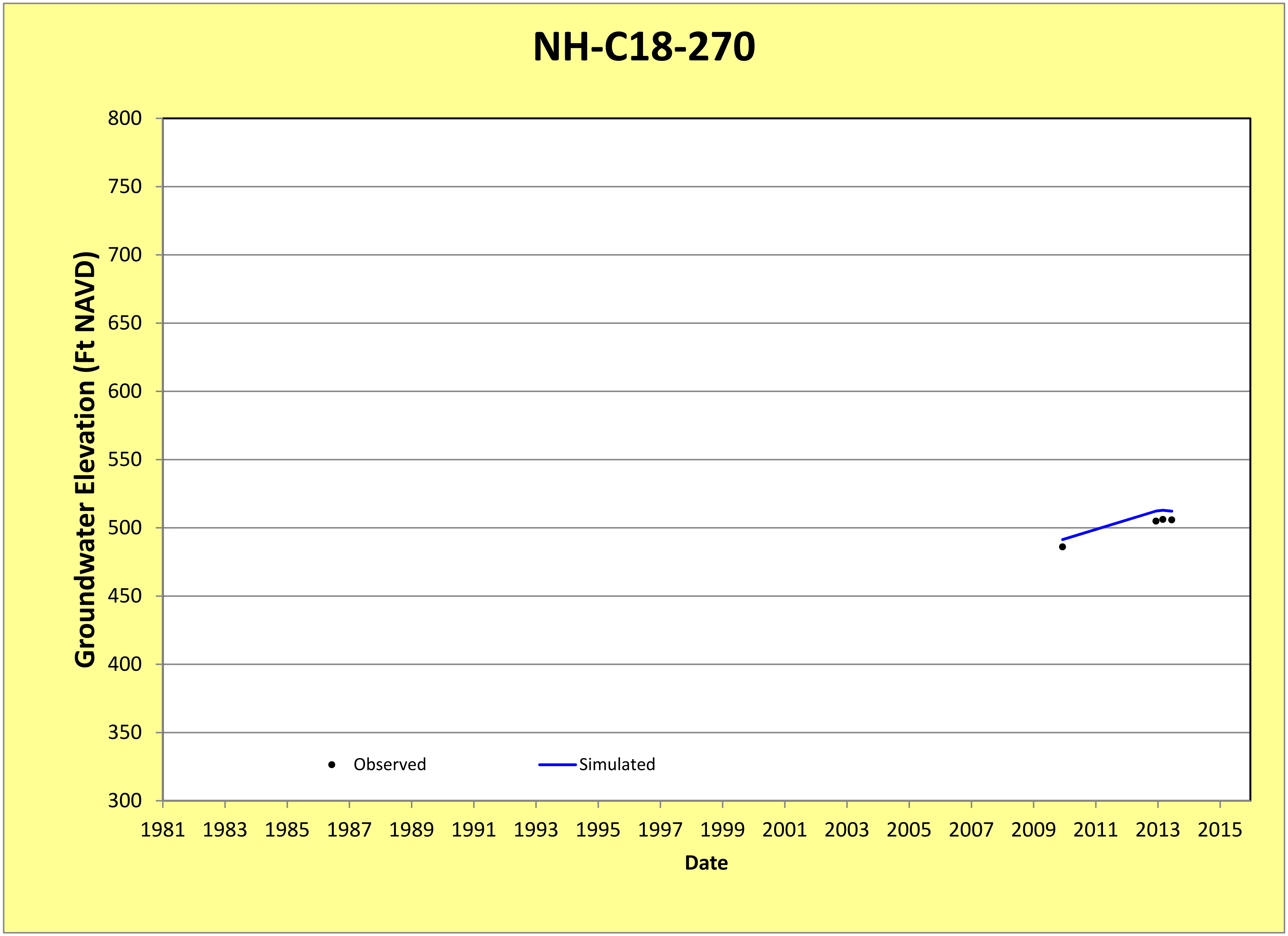
2013
2015
Date
Observed
Simulated



NH-C18-270
Groundwater Elevation (Ft NAVD)
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750
700
650
600
550
500
450
400
350
300
Observed
Simulated
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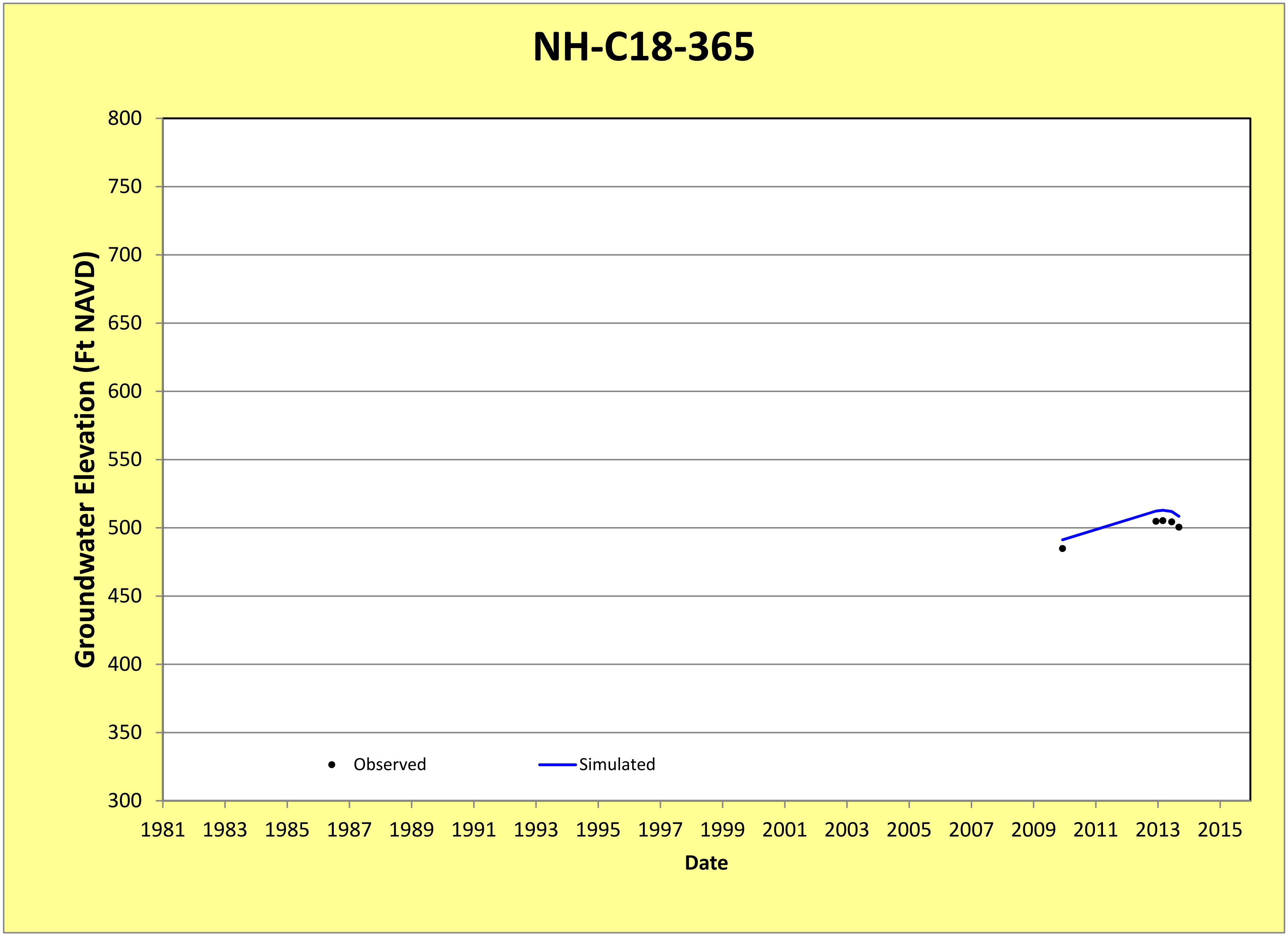
2015
Date


NH-C18-365
Groundwater Elevation (Ft NAVD)
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750
700
650
600
550
500
450
400
350
300
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1987
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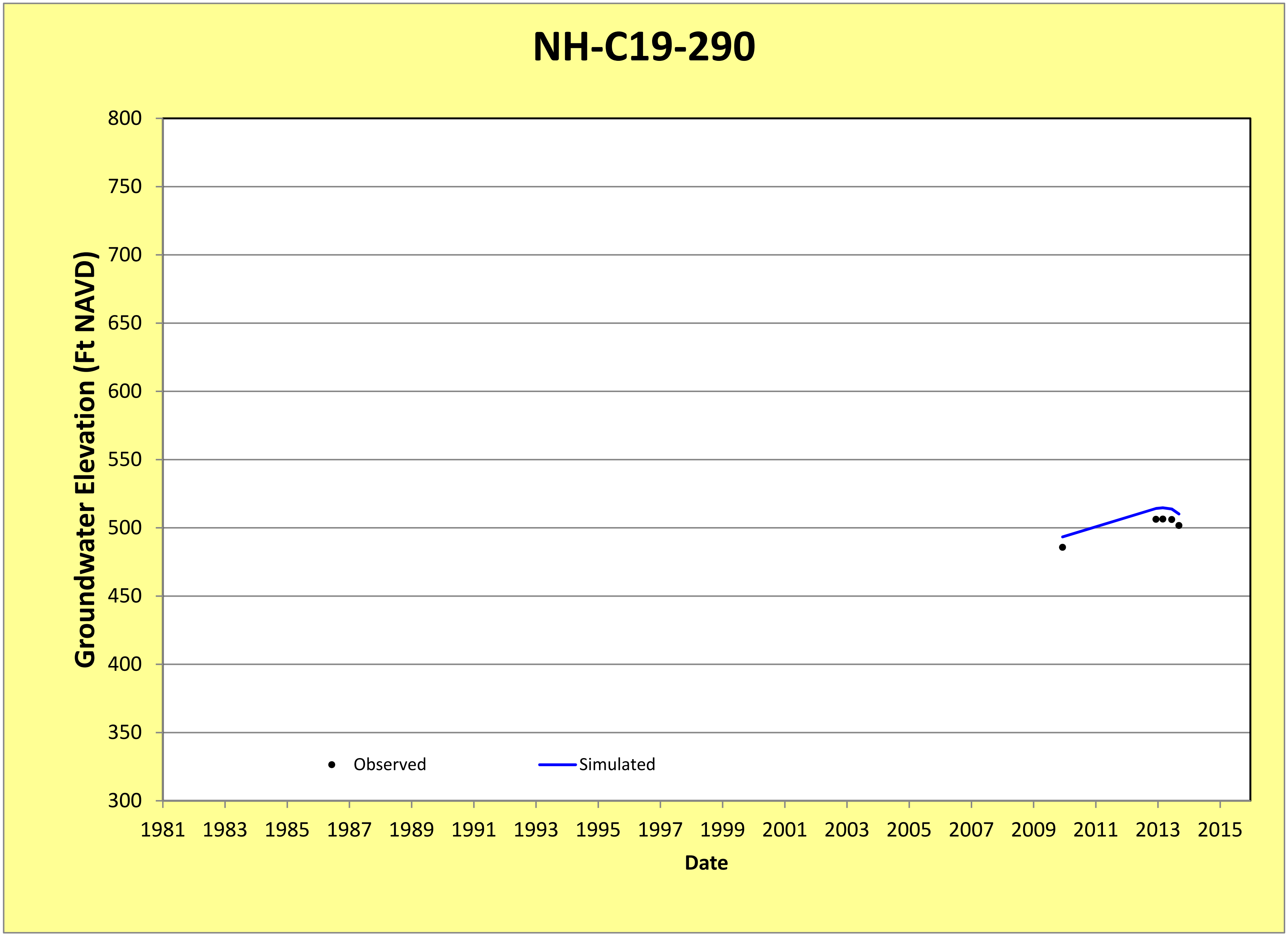
Date
Observed
Simulated


NH-C19-290
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
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2015
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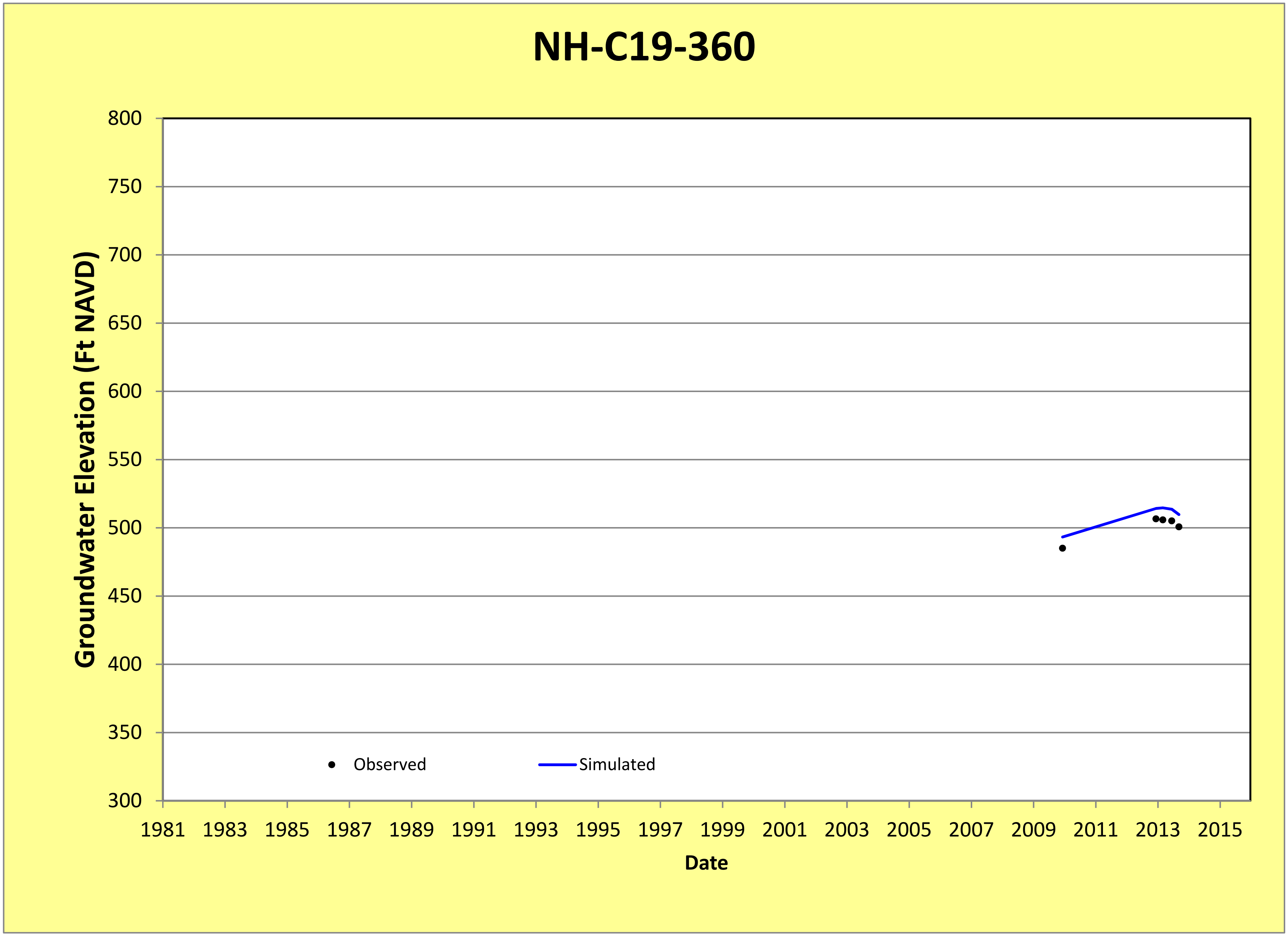
NH-C19-360
Groundwater Elevation (Ft NAVD)
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700
650
600
550
500
450
400
350
300
Observed
Simulated
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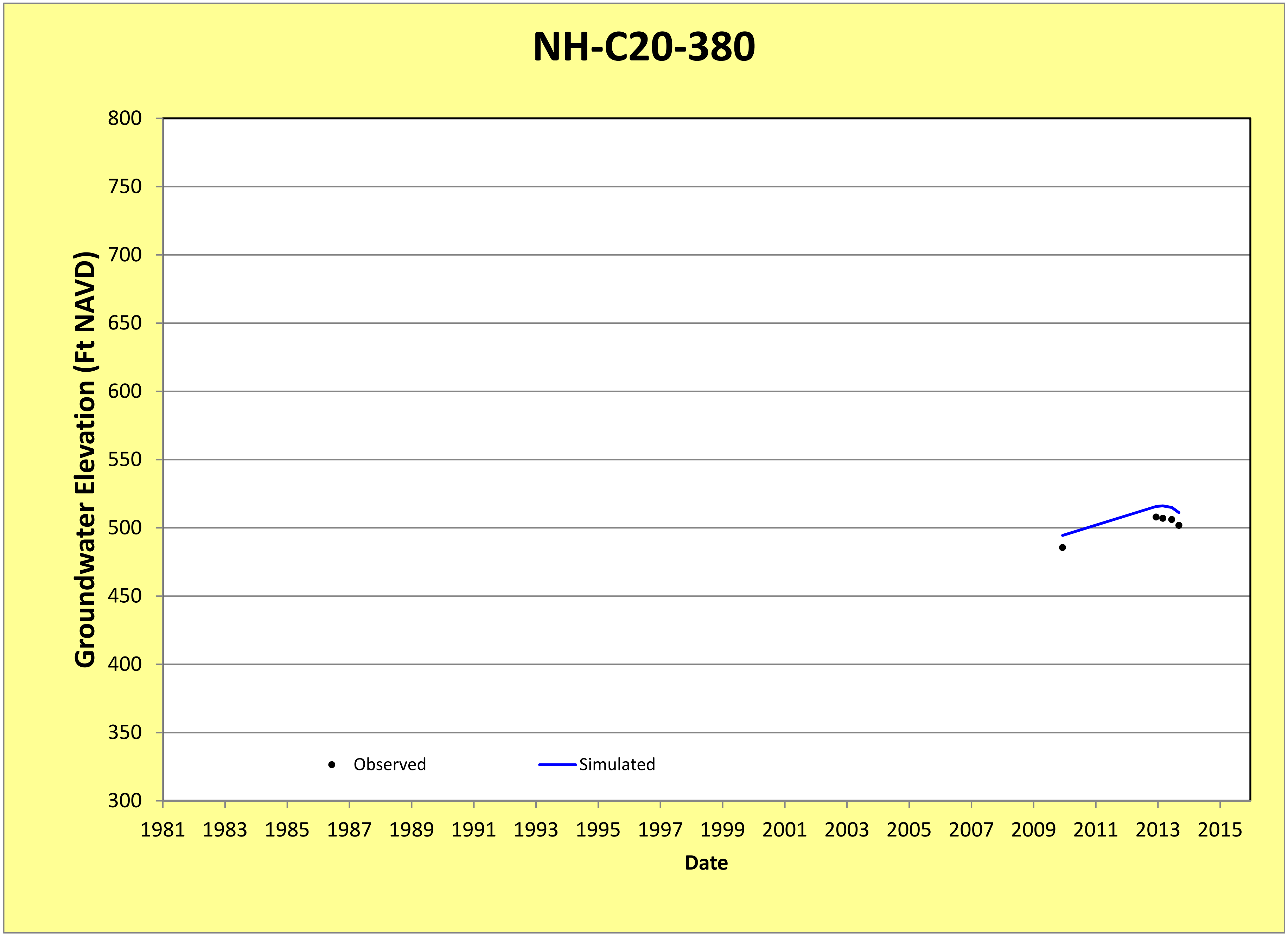
2015
Date


NH-C20-380
Groundwater Elevation (Ft NAVD)
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750
700
650
600
550
500
450
400
350
300
Observed
Simulated
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2011
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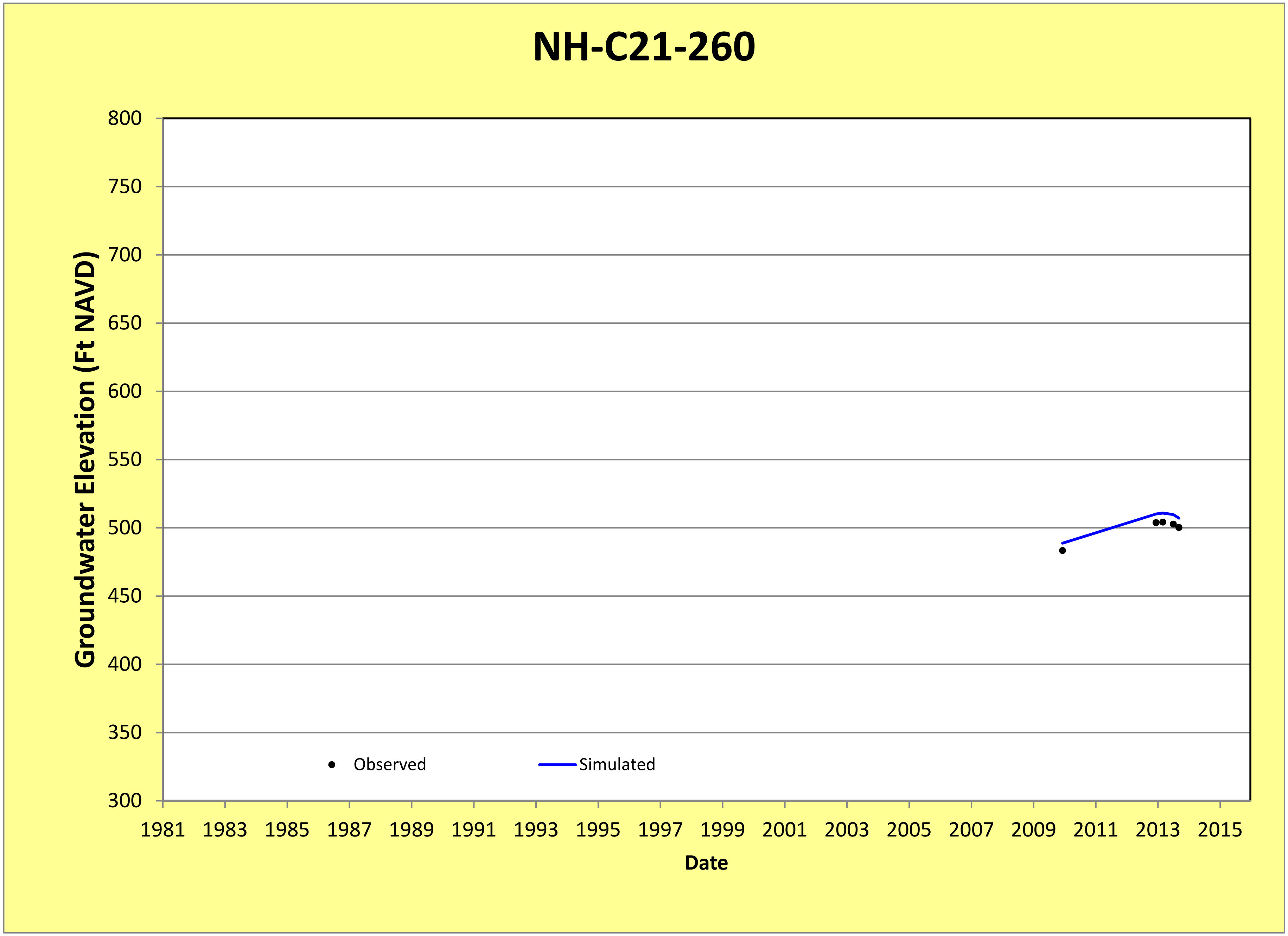
2015
Date


NH-C21-260
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
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1983
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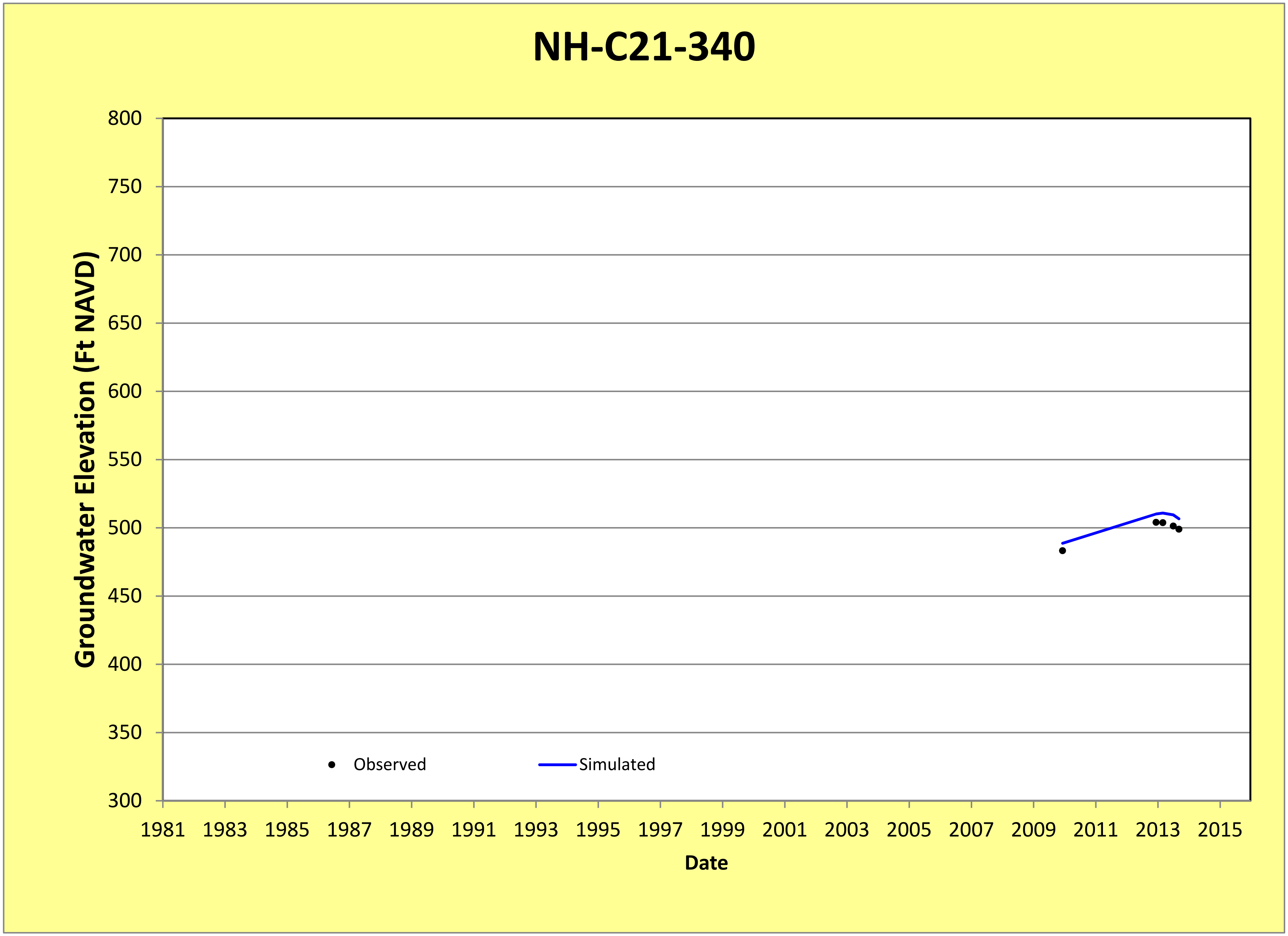
2015
Date


NH-C21-340
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
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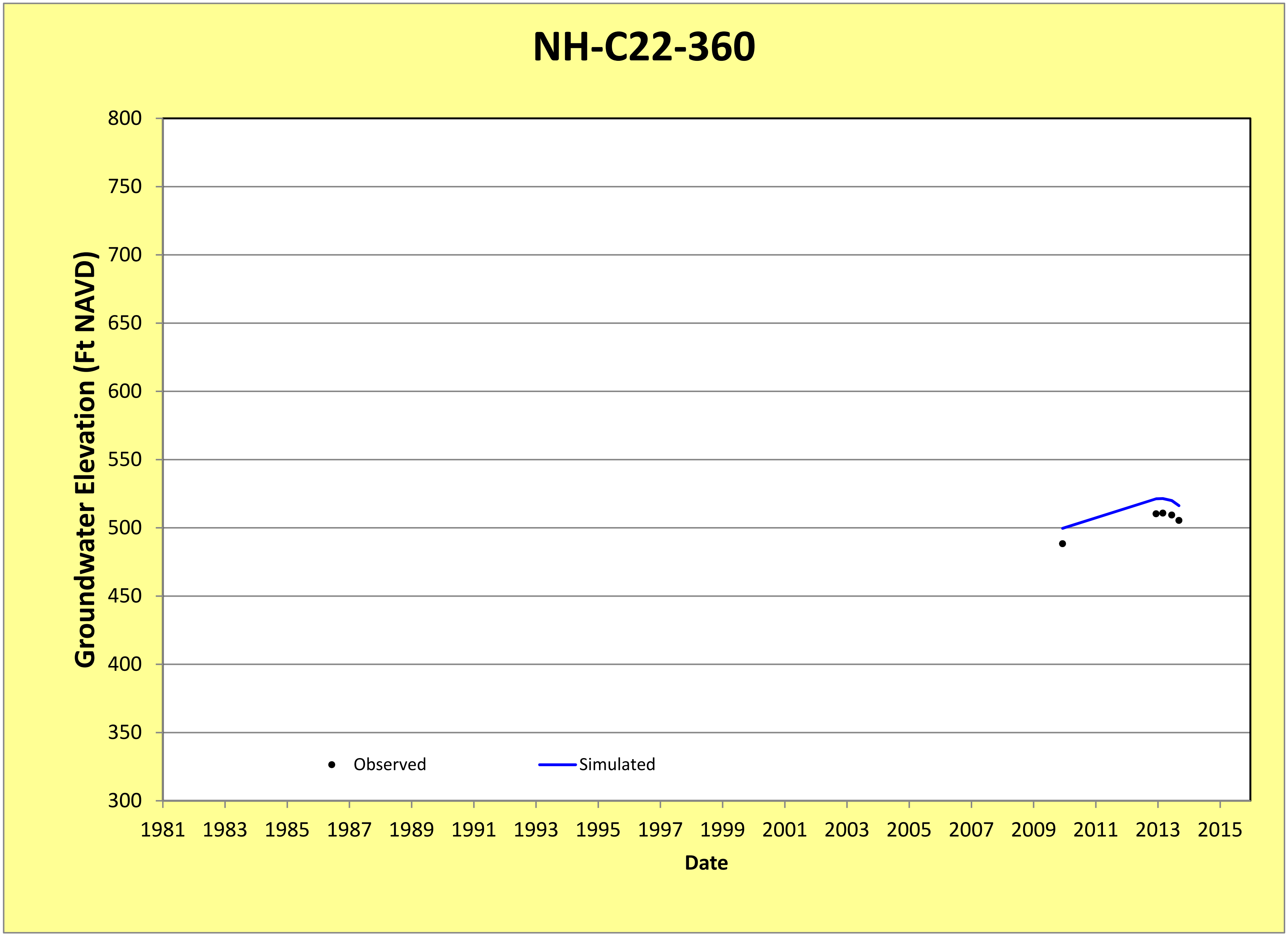
2007
2009
2011
2013
2015
Date



NH-C22-360
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
1983
1985
1987
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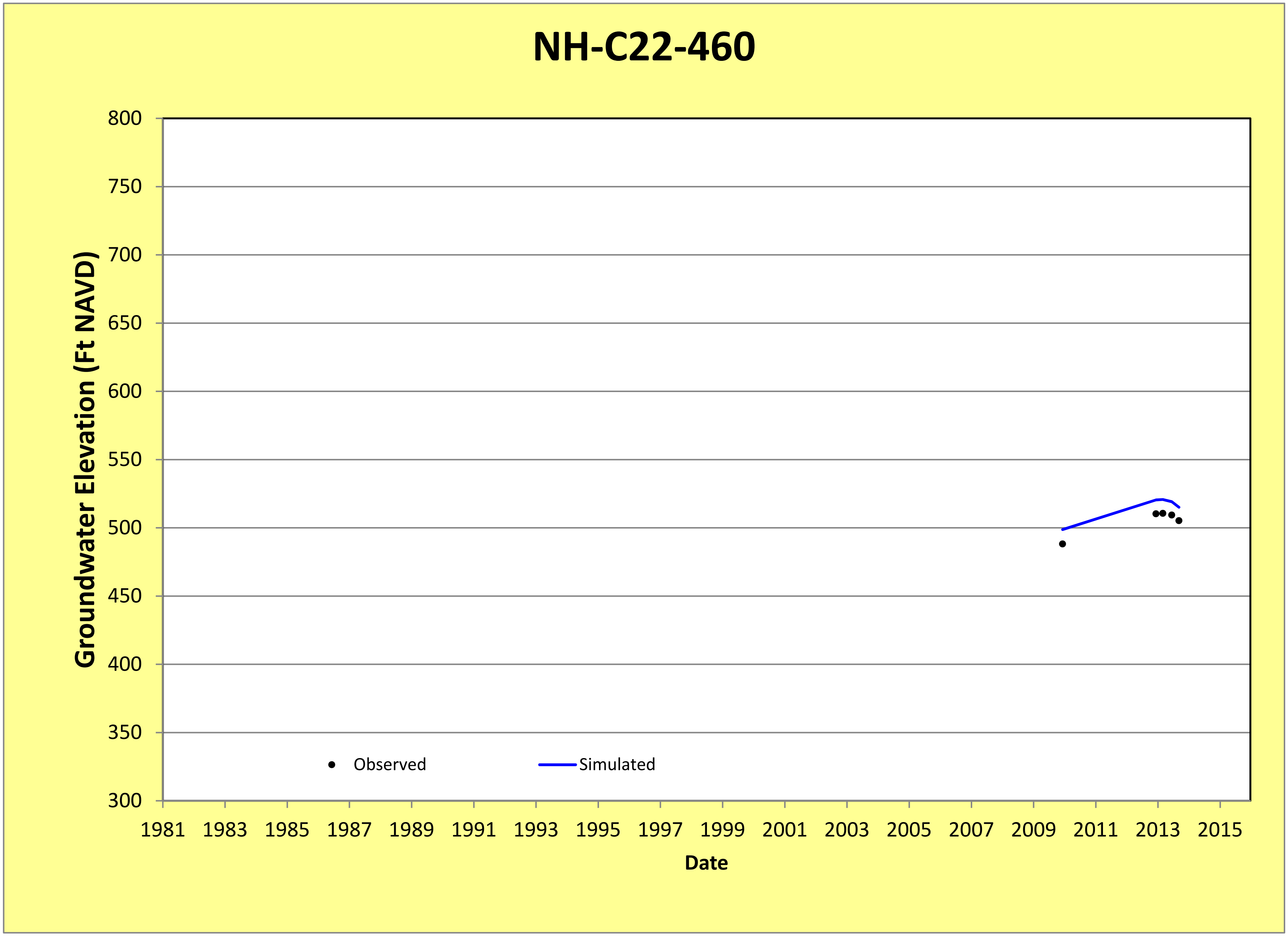
2011
2013
2015
Date



NH-C22-460
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
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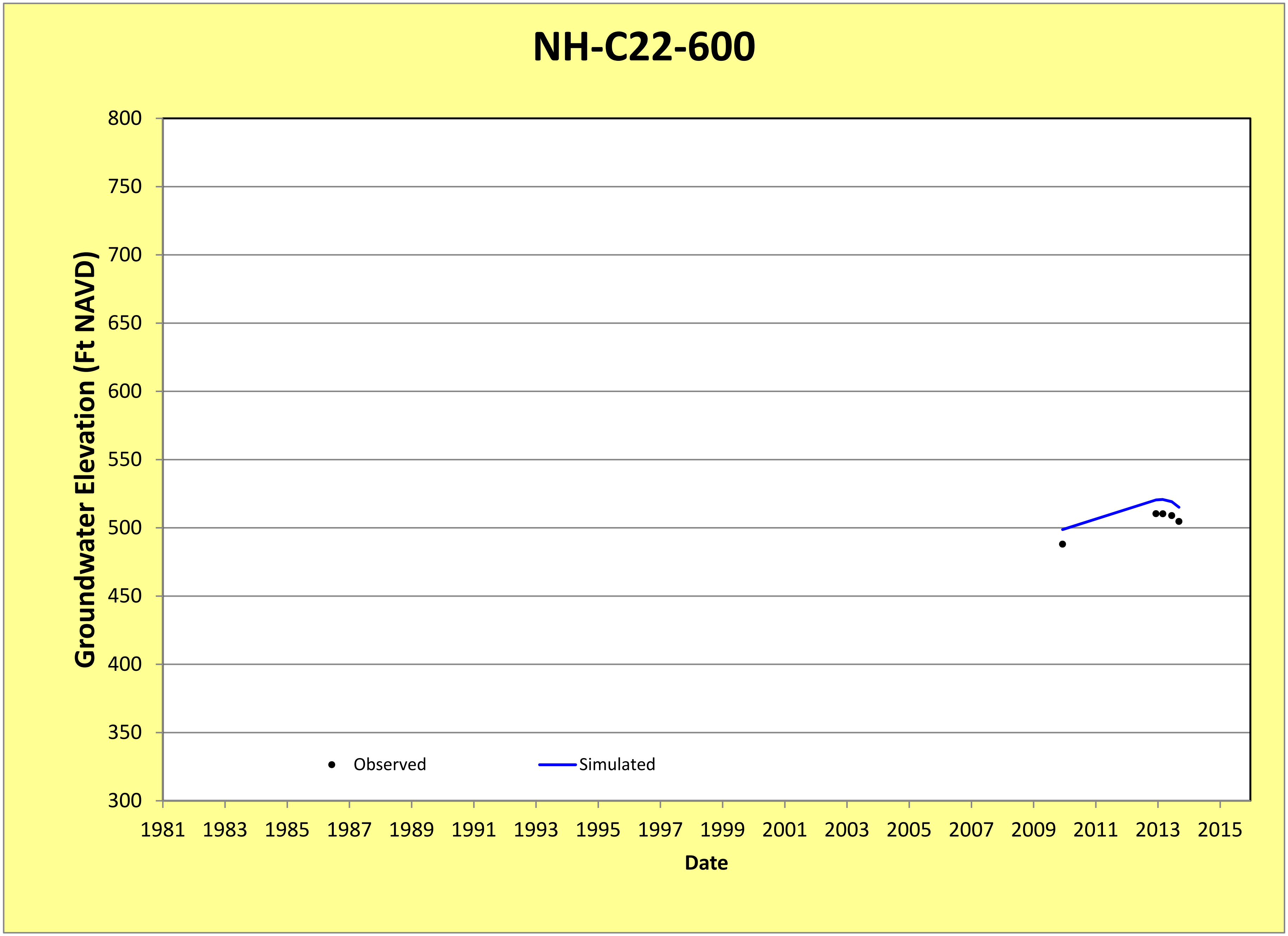
2011
2013
2015
Date


NH-C22-600
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
1981
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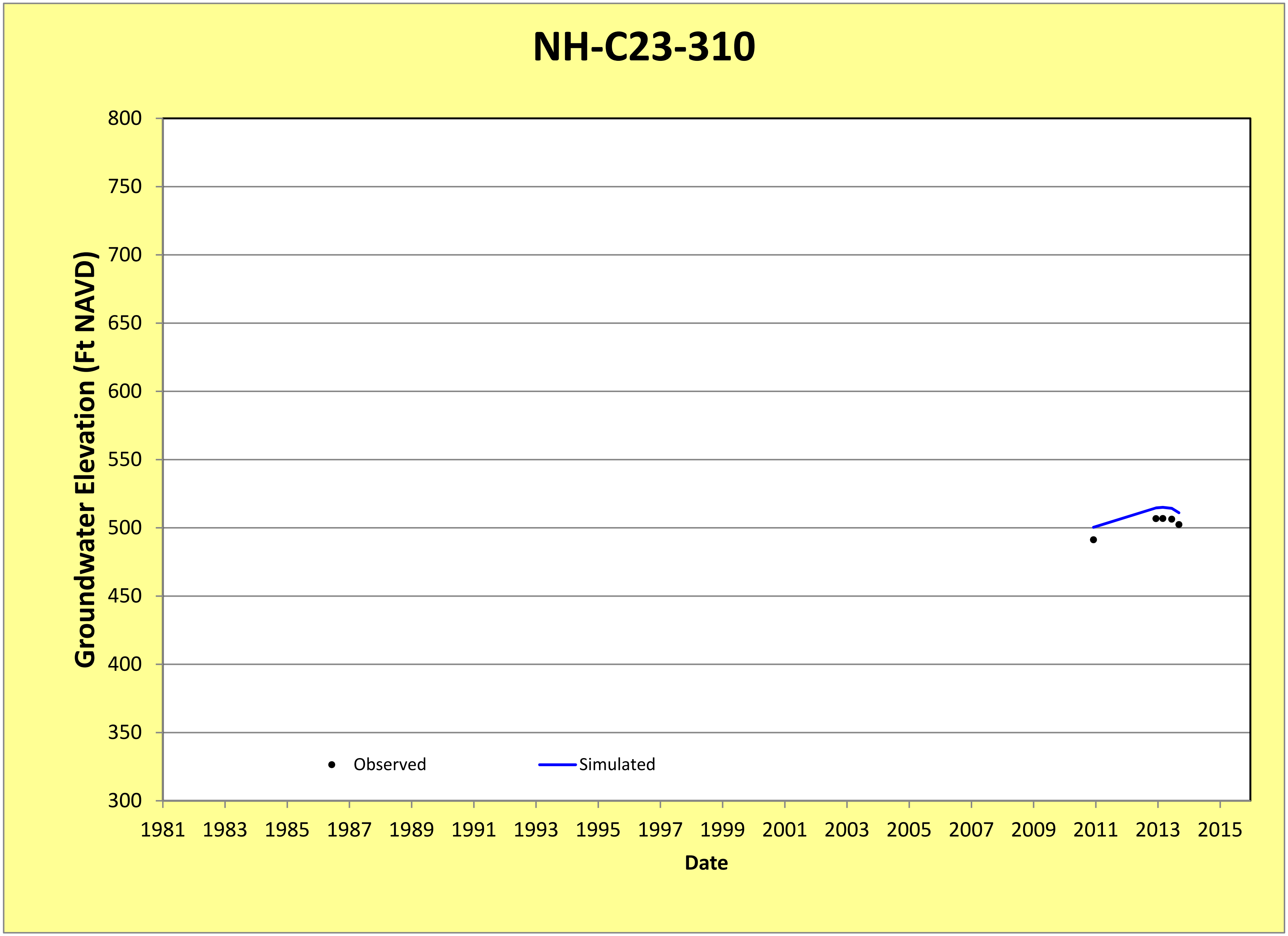
2009
2011
2013
2015
Date
Observed
Simulated



NH-C23-310
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
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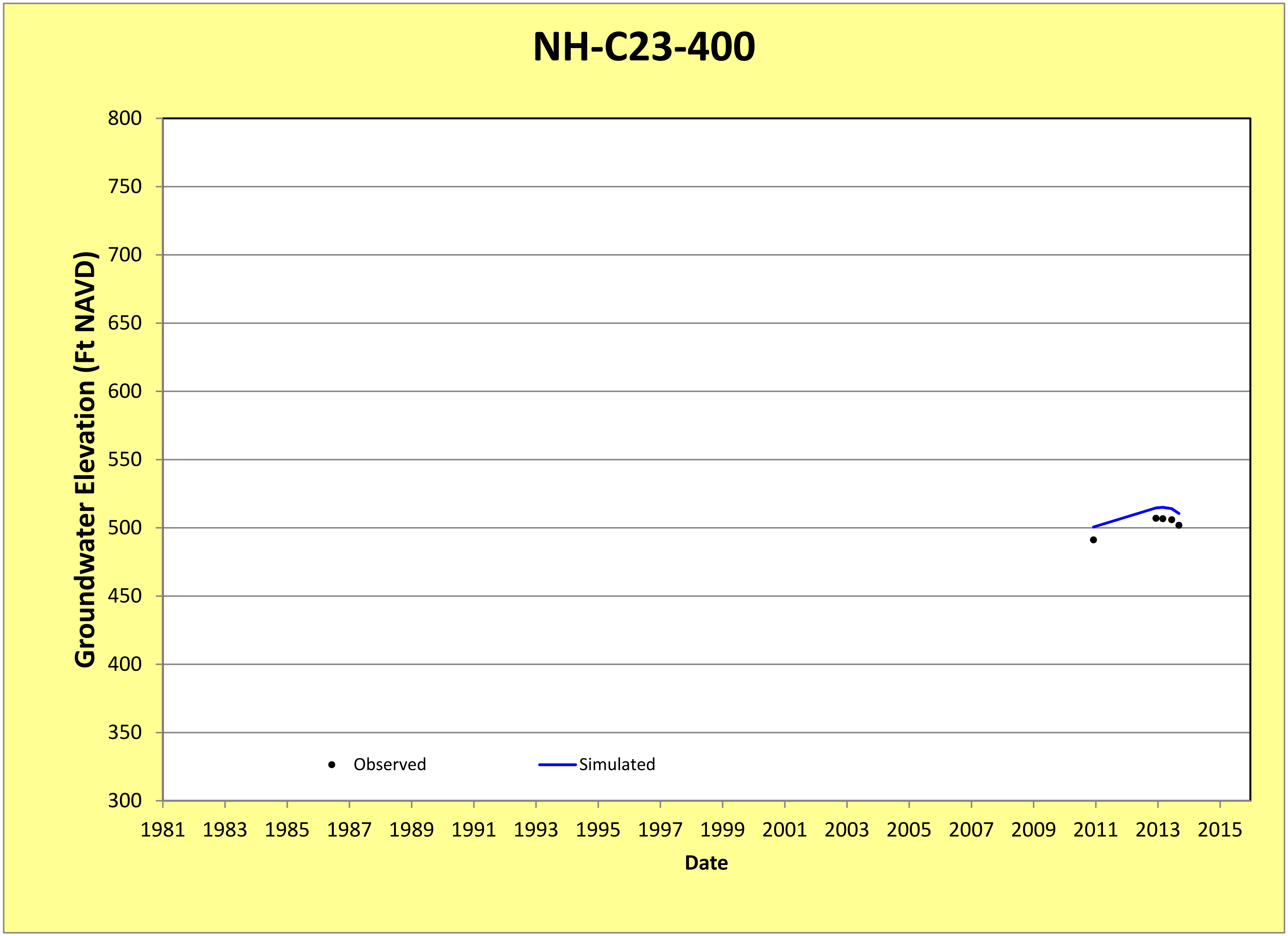
2007
2009
2011
2013
2015
Date


NH-C23-400
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
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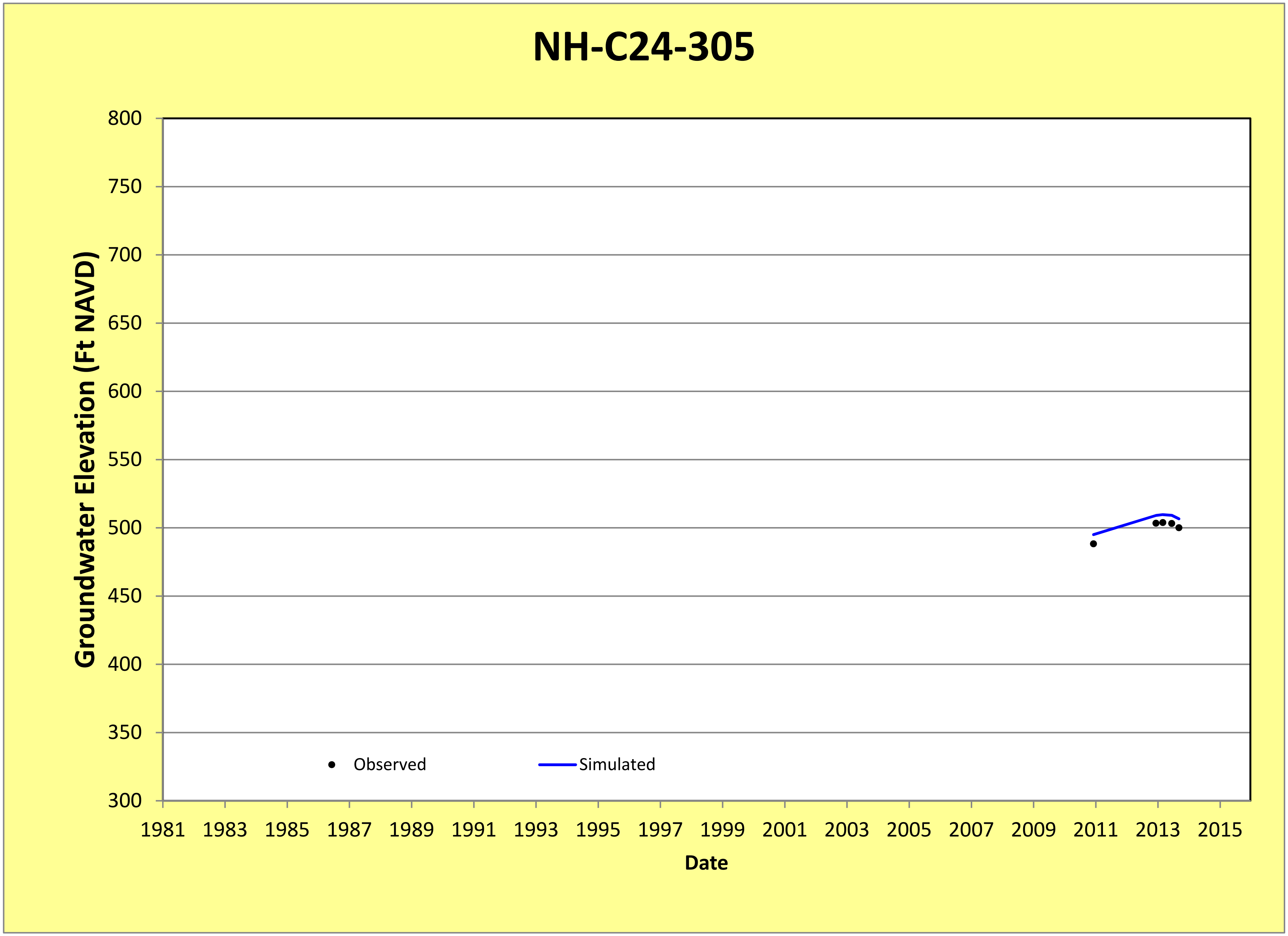
2009
2011
2013
2015
Date


NH-C24-305
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
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1987
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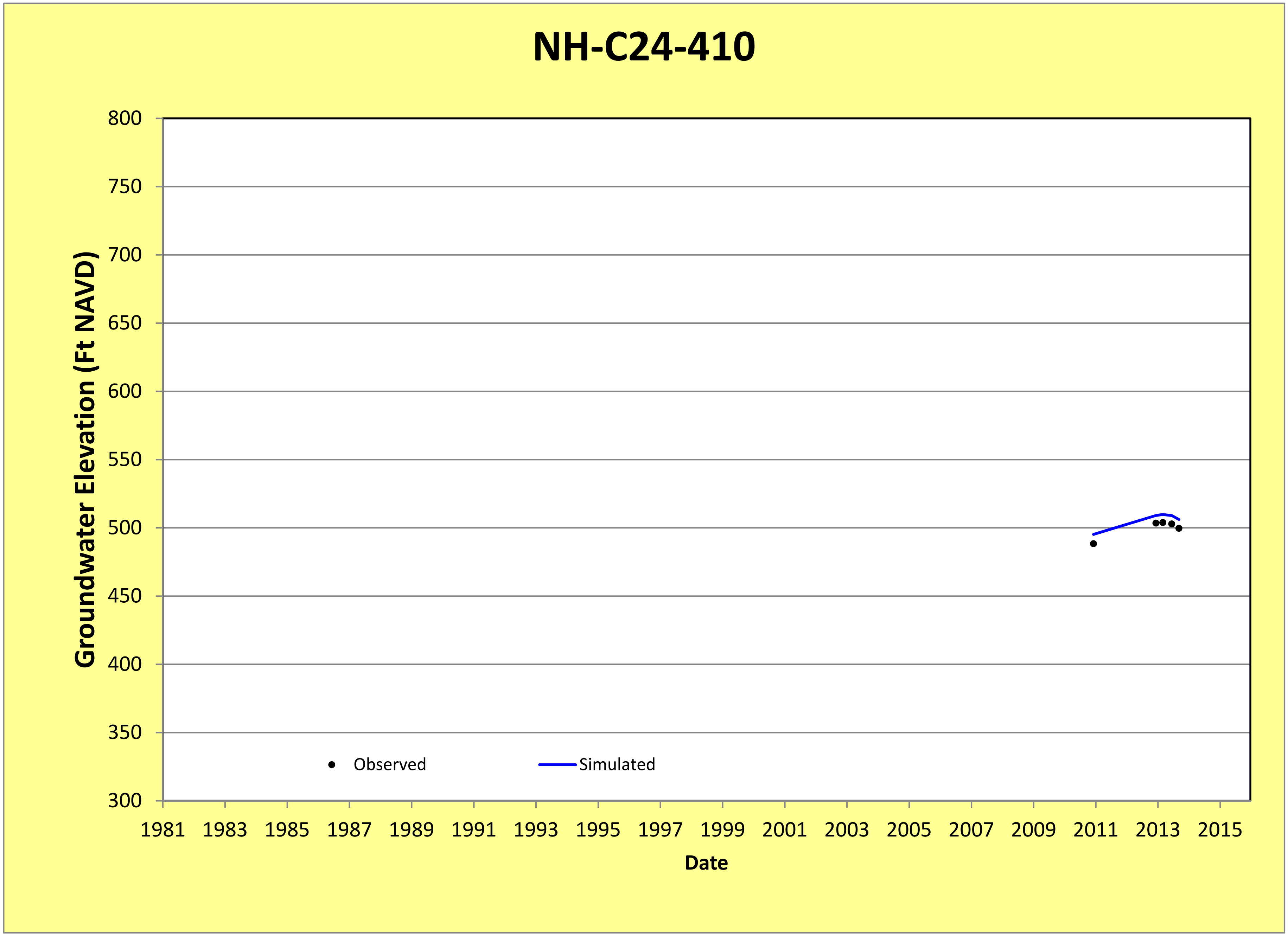
2011
2013
2015
Date


NH-C24-410
Groundwater Elevation (Ft NAVD)
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750
700
650
600
550
500
450
400
350
300
1981
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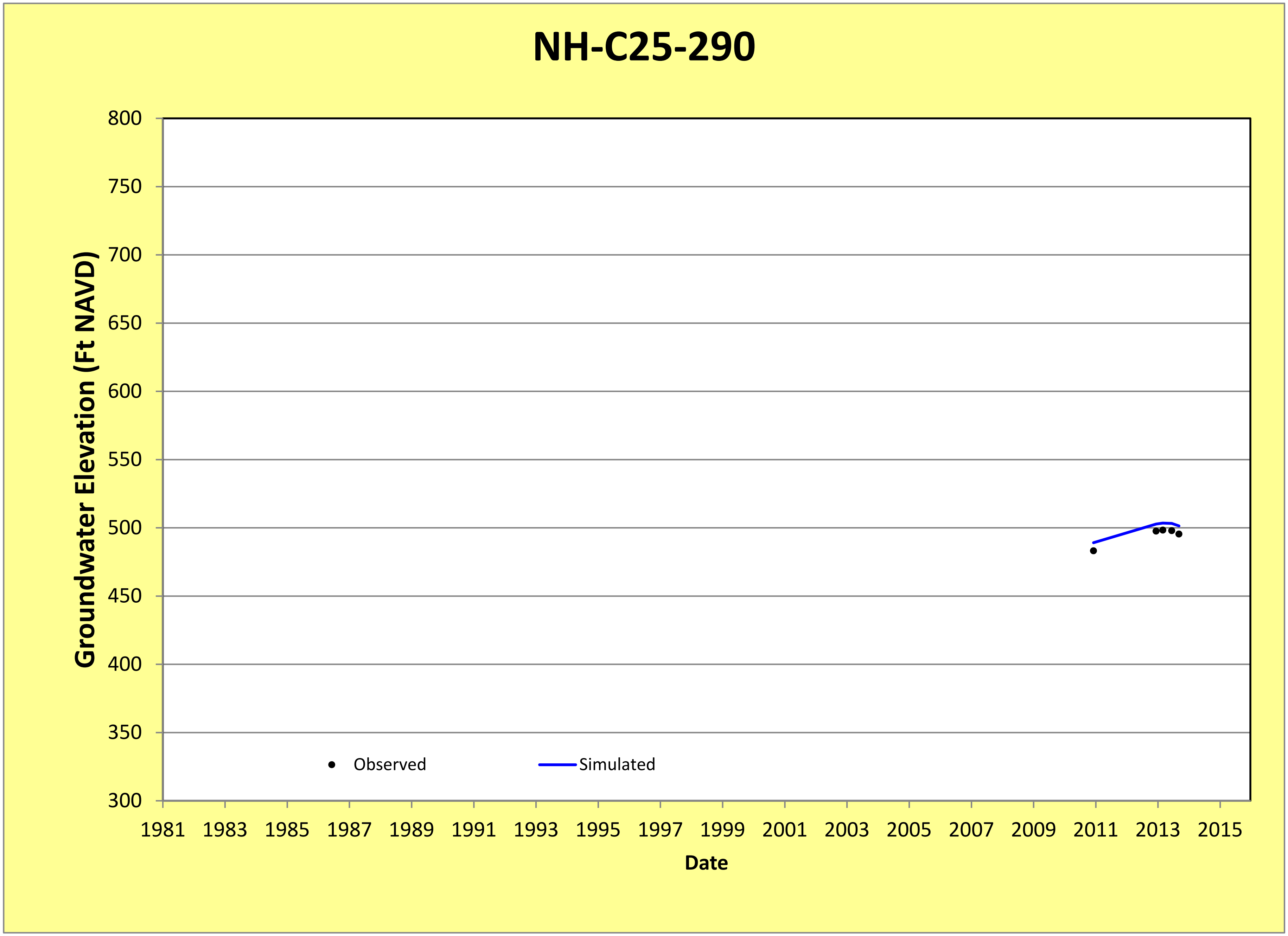
2009
2011
2013
2015
Date
Observed
Simulated


NH-C25-290
Groundwater Elevation (Ft NAVD)
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750
700
650
600
550
500
450
400
350
300
1981
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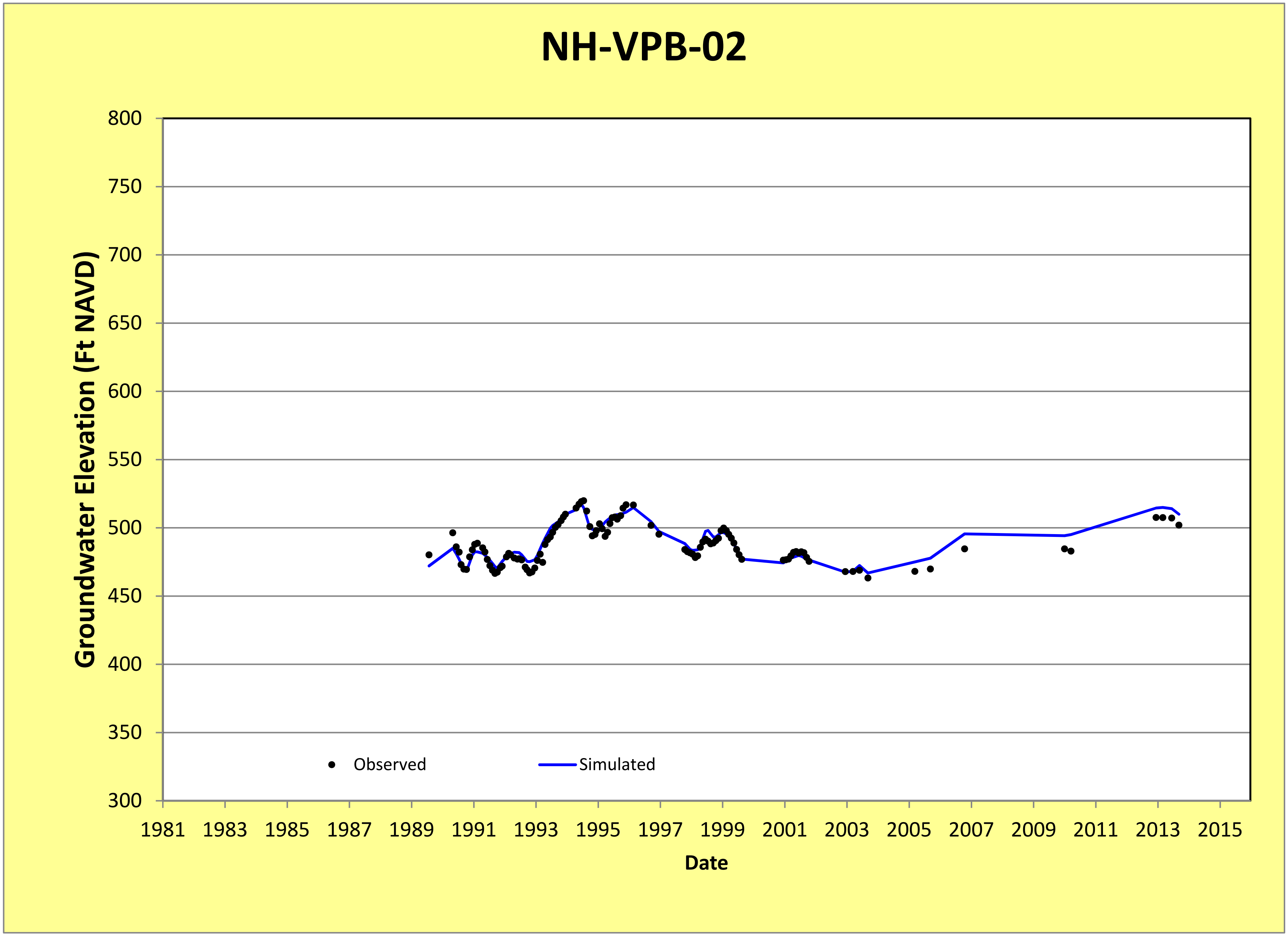
2009
2011
2013
2015
Date
Observed
Simulated



NH-VPB-02
Groundwater Elevation (Ft NAVD)
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750
700
650
600
550
500
450
400
350
300
Observed
Simulated
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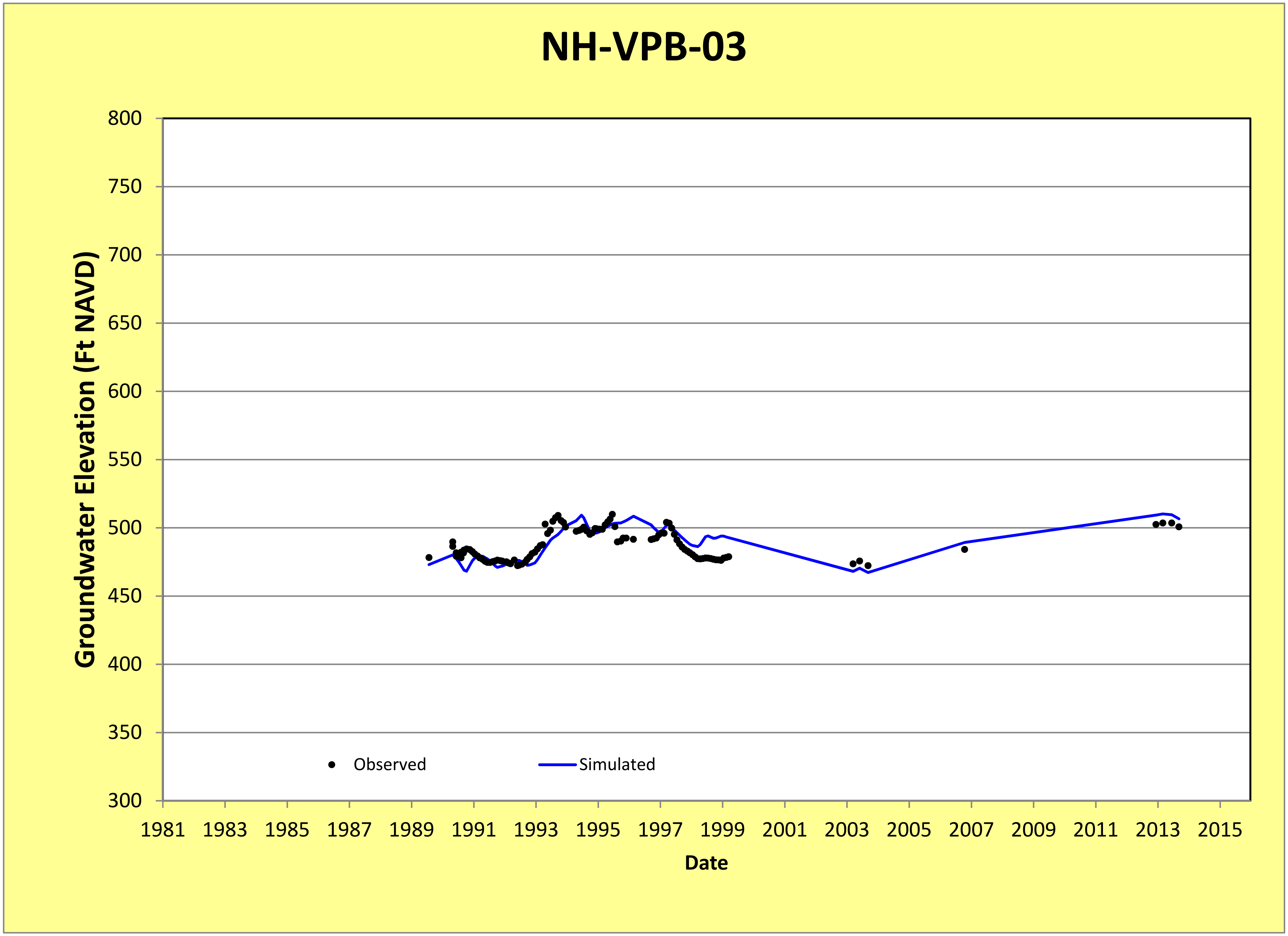
Date


NH-VPB-03
Groundwater Elevation (Ft NAVD)
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700
650
600
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500
450
400
350
300
1981
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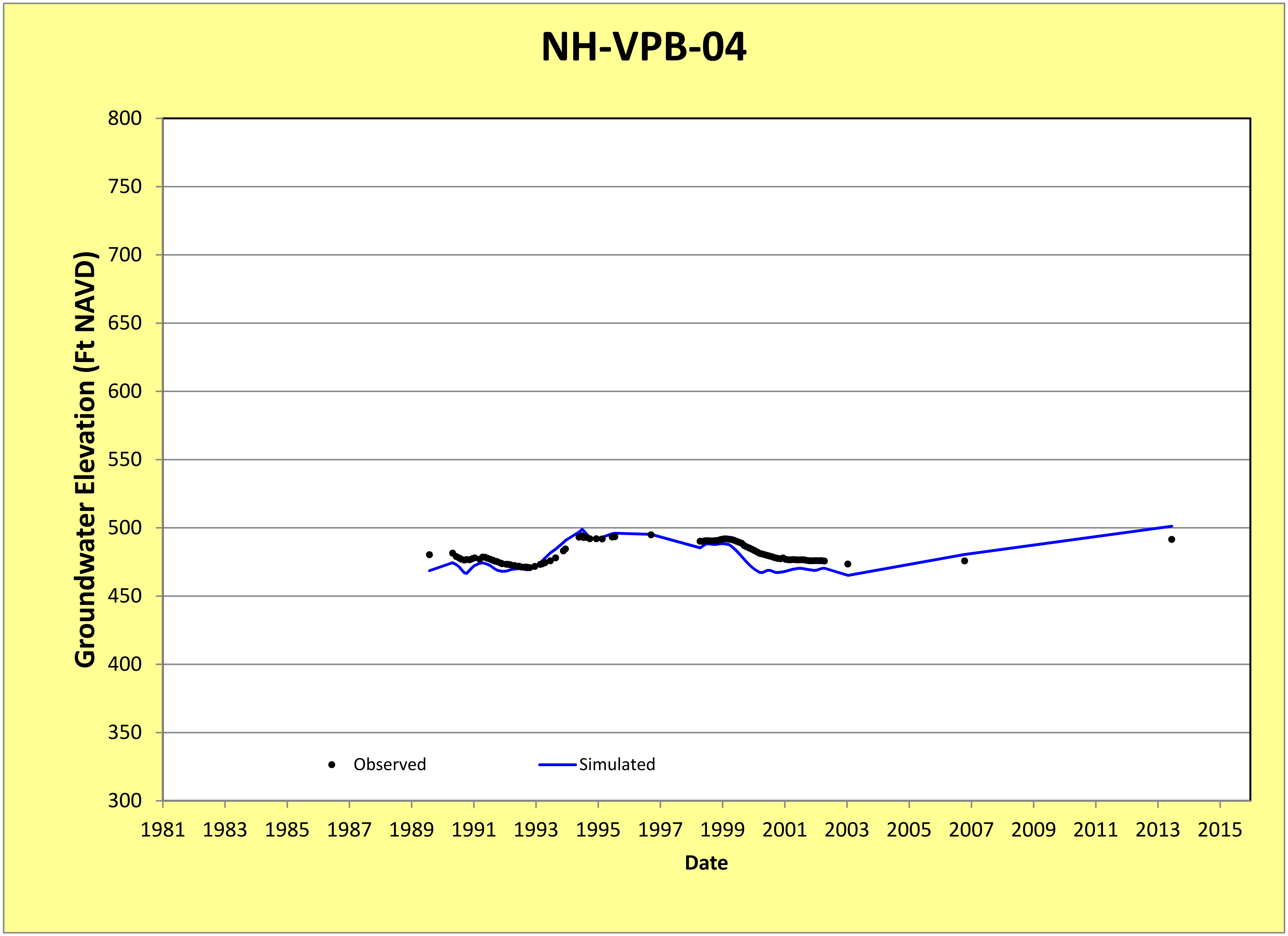
2013
2015
Date
Observed
Simulated


NH-VPB-04
Groundwater Elevation (Ft NAVD)
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550
500
450
400
350
300
1981
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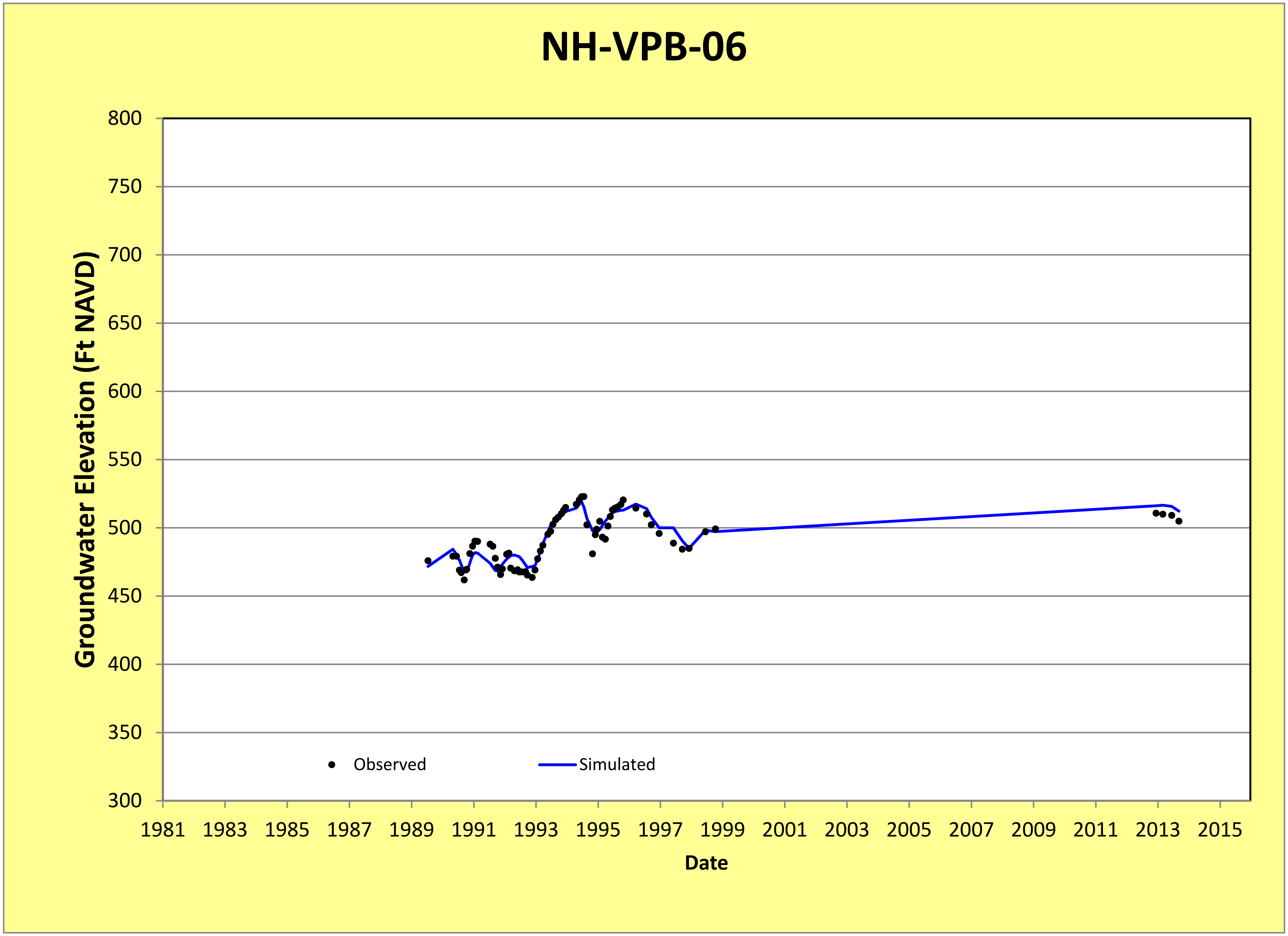
2015
Date
Observed
Simulated


NH-VPB-06
Groundwater Elevation (Ft NAVD)
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750
700
650
600
550
500
450
400
350
300
Observed
Simulated
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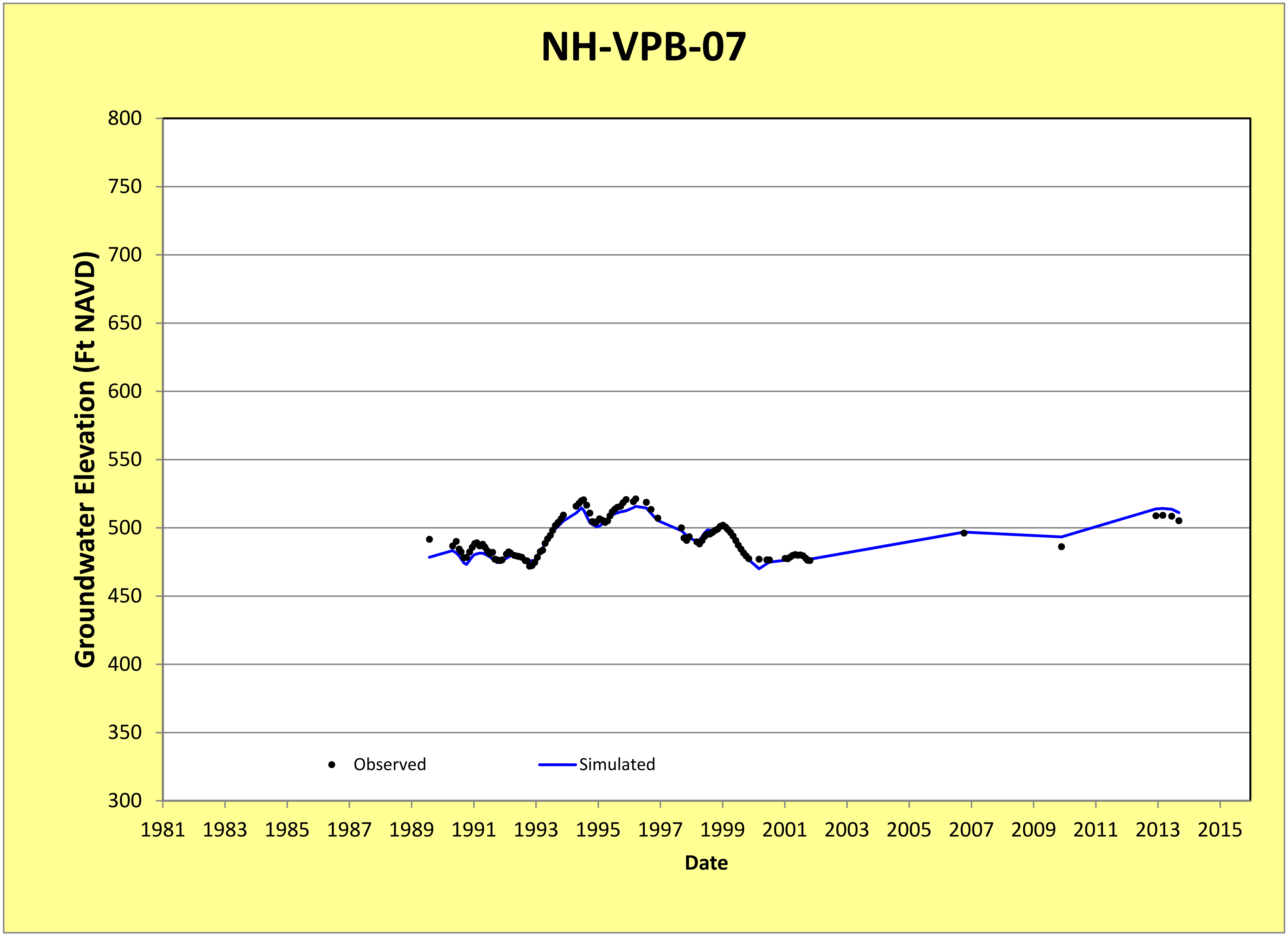
2015
Date



NH-VPB-07
Groundwater Elevation (Ft NAVD)
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750
700
650
600
550
500
450
400
350
300
Observed
Simulated
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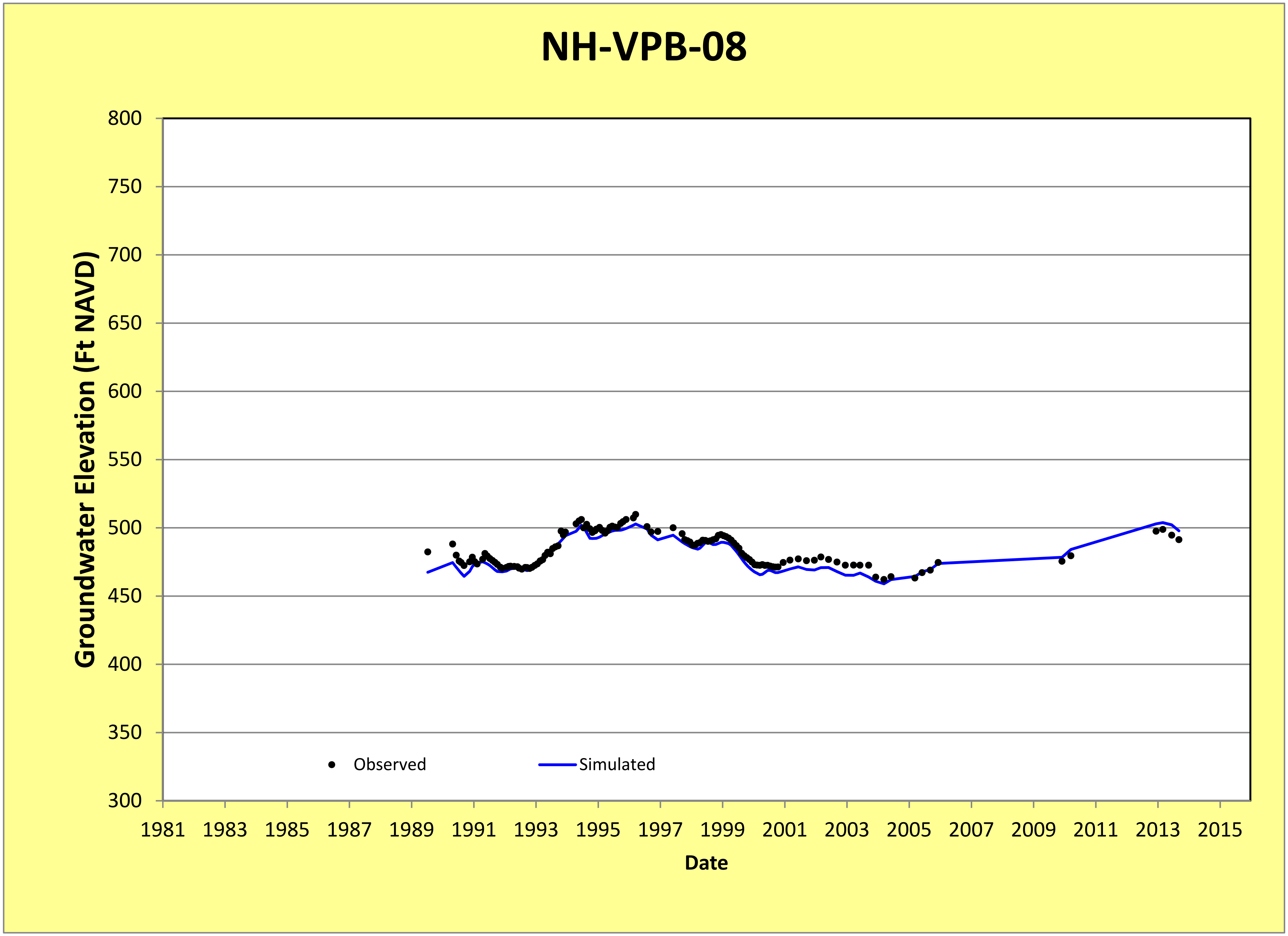
2015
Date



NH-VPB-08
Groundwater Elevation (Ft NAVD)
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750
700
650
600
550
500
450
400
350
300
1981
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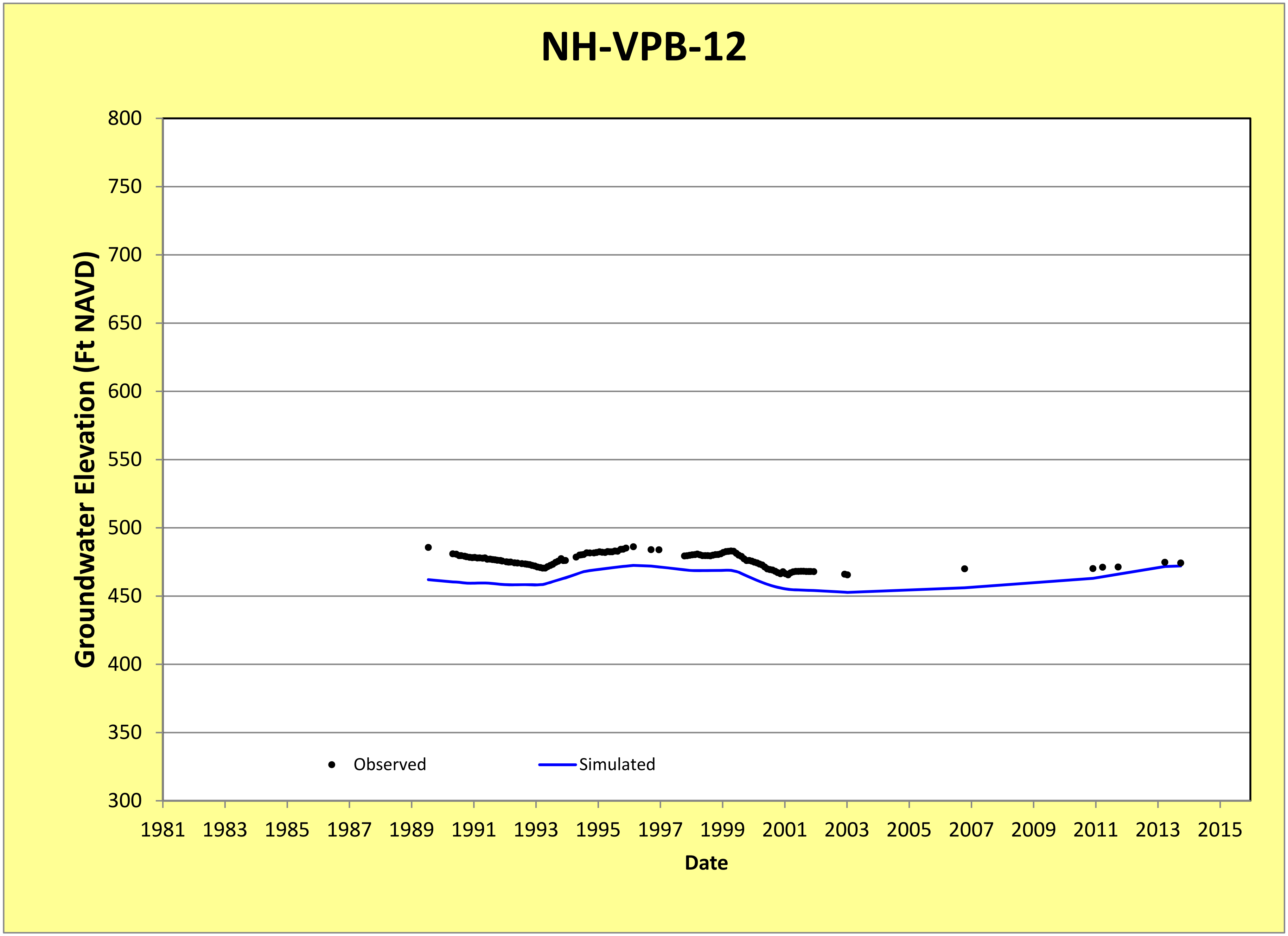
2009
2011
2013
2015
Date
Observed
Simulated


NH-VPB-12
Groundwater Elevation (Ft NAVD)
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700
650
600
550
500
450
400
350
300
Observed
Simulated
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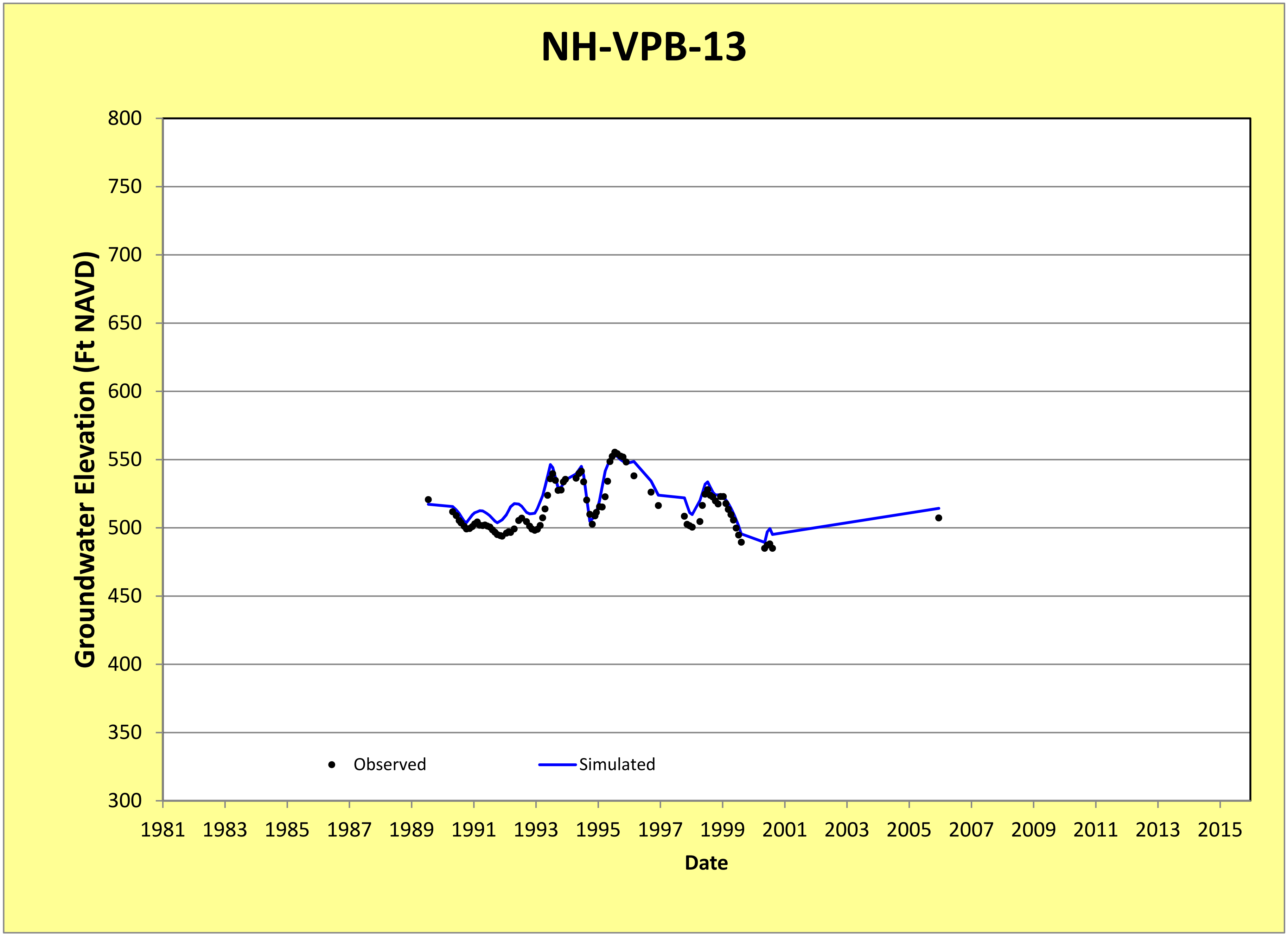
2015
Date



NH-VPB-13
Groundwater Elevation (Ft NAVD)
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750
700
650
600
550
500
450
400
350
300
Observed
Simulated
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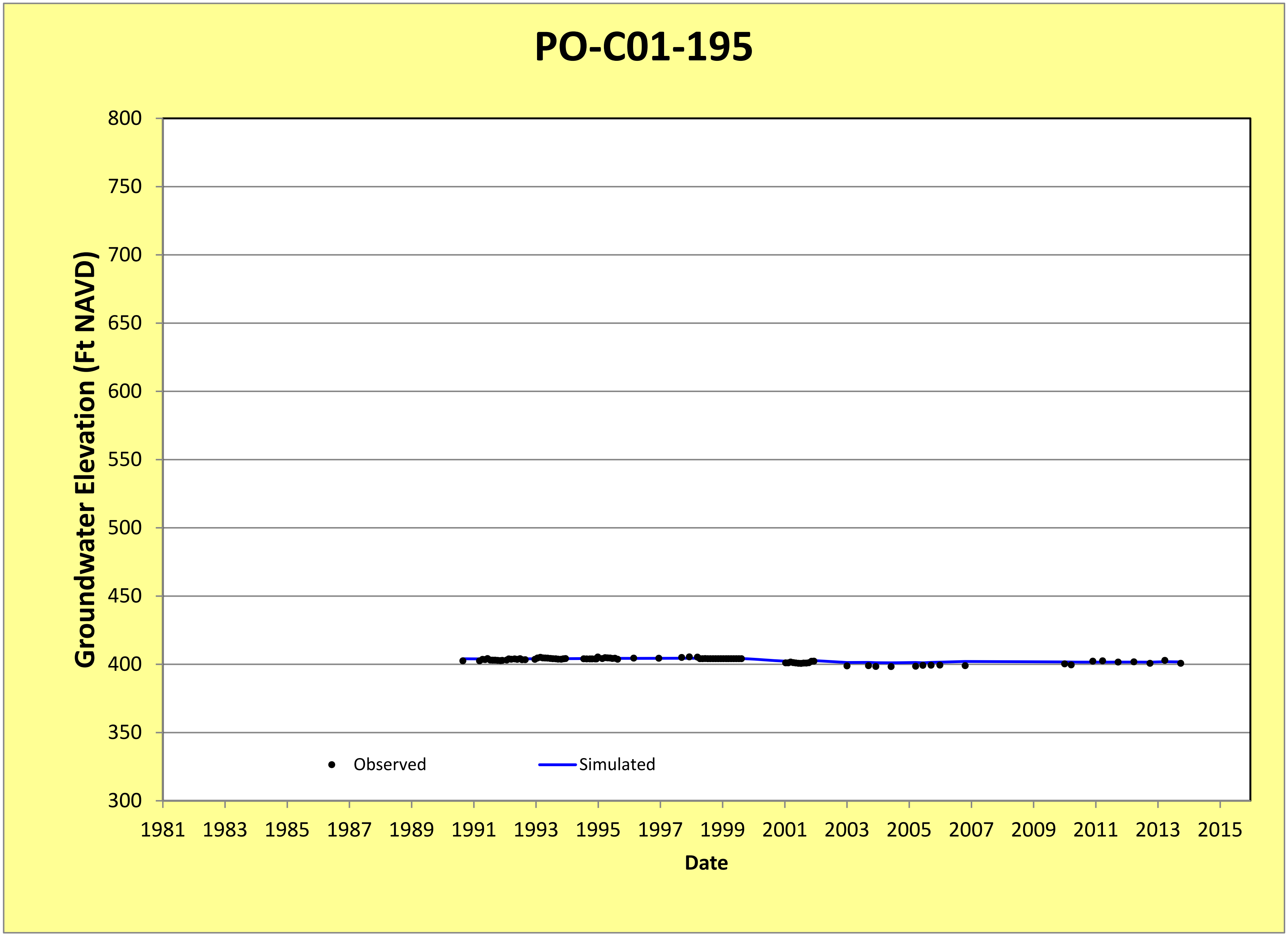
2013
2015
Date


PO-C01-195
Groundwater Elevation (Ft NAVD)
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750
700
650
600
550
500
450
400
350
300
1981
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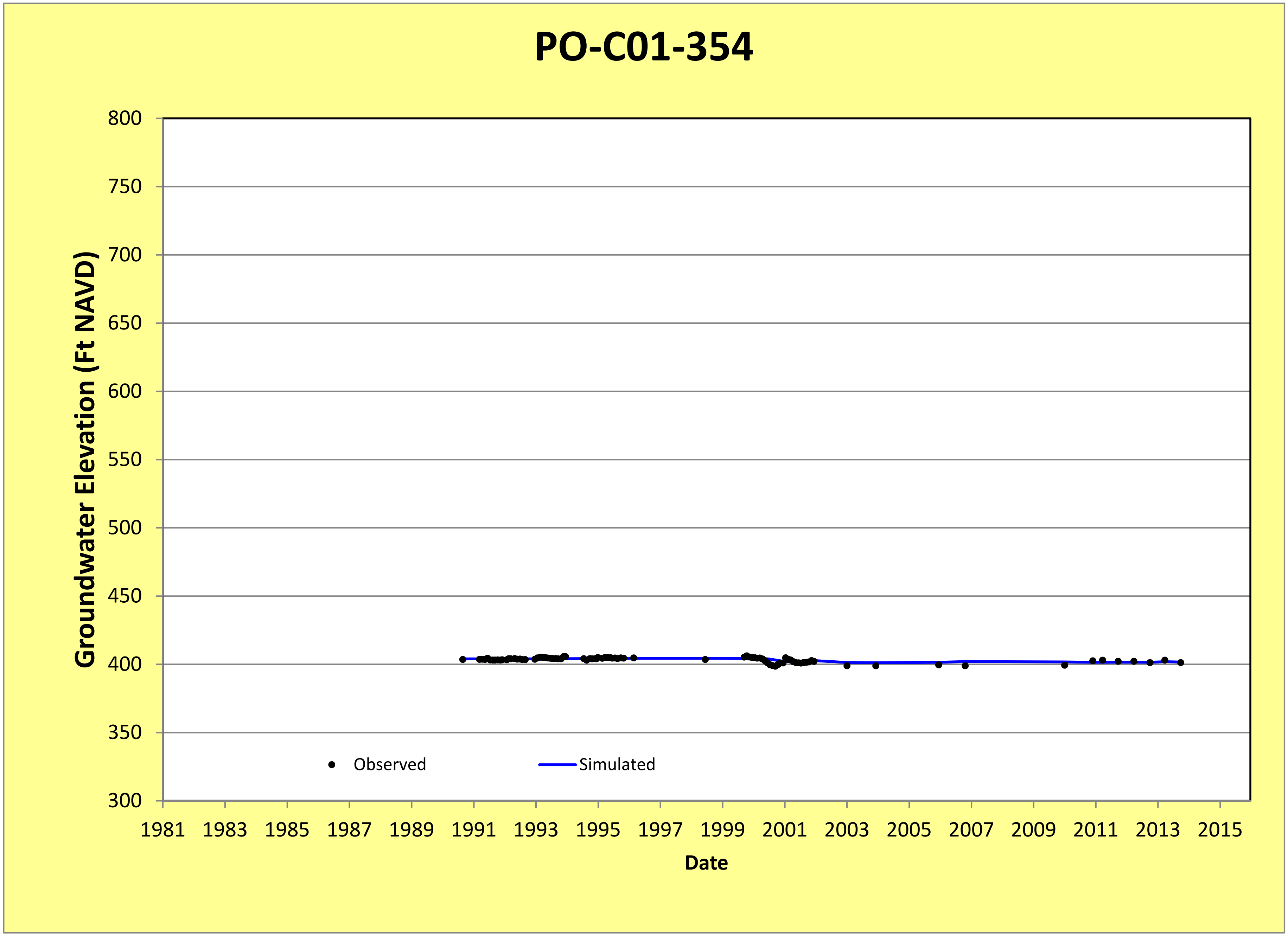
2009
2011
2013
2015
Date
Observed
Simulated



PO-C01-354
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
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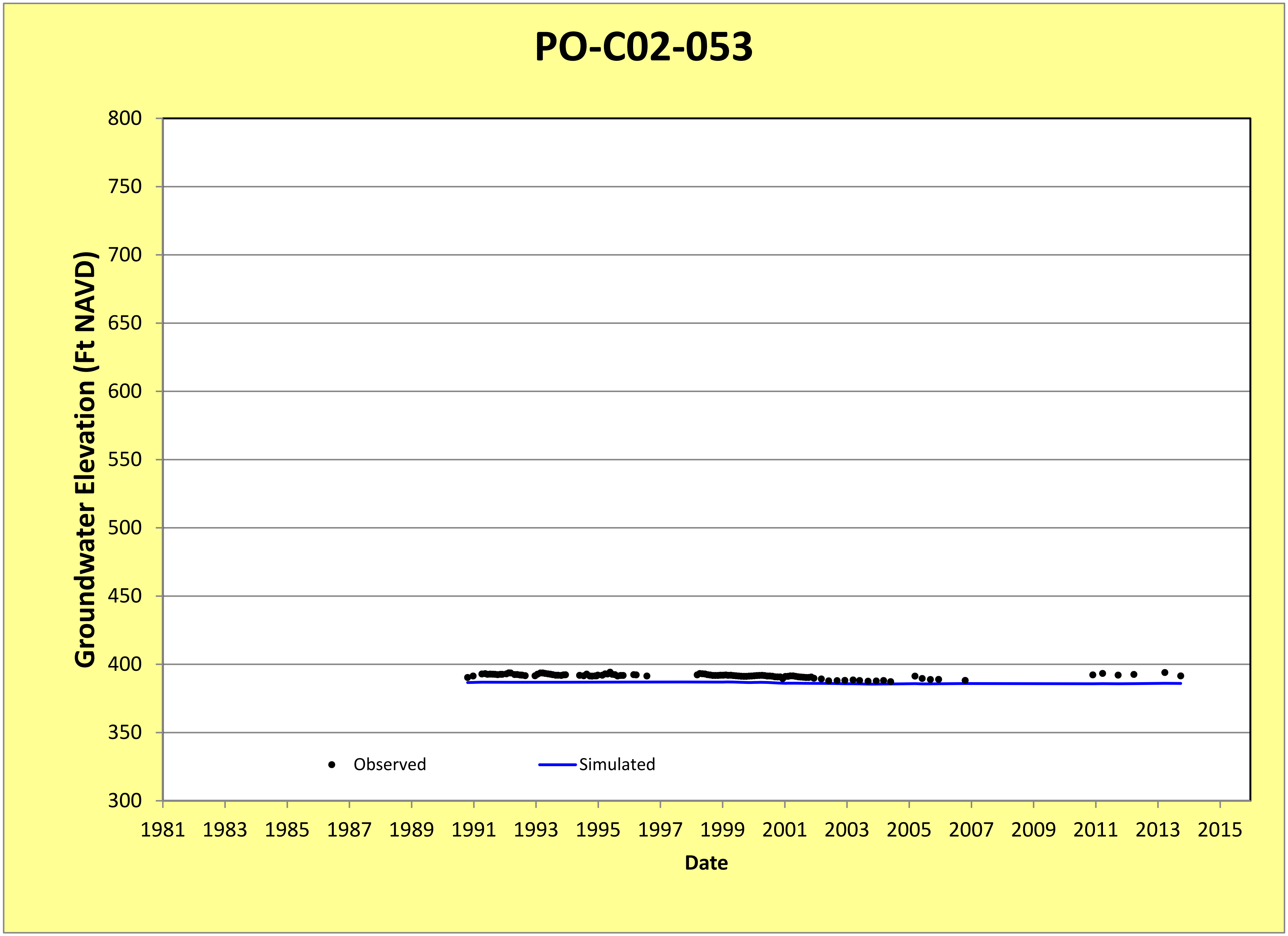
2011
2013
2015
Date



PO-C02-053
Groundwater Elevation (Ft NAVD)
800
750
700
650
600
550
500
450
400
350
300
Observed
Simulated
1981
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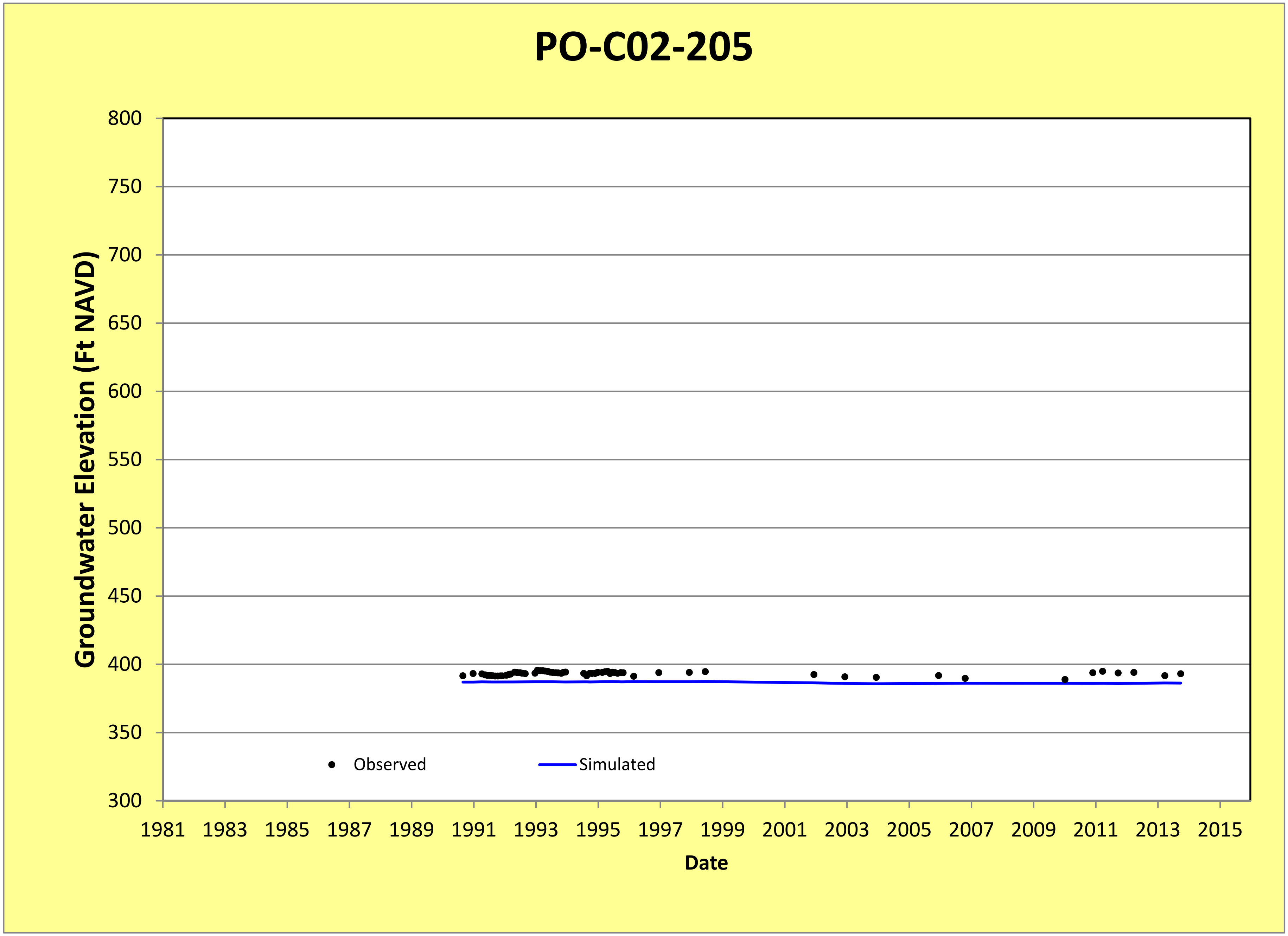
2011
2013
2015
Date


PO-C02-205
Groundwater Elevation (Ft NAVD)
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750
700
650
600
550
500
450
400
350
300
Observed
Simulated
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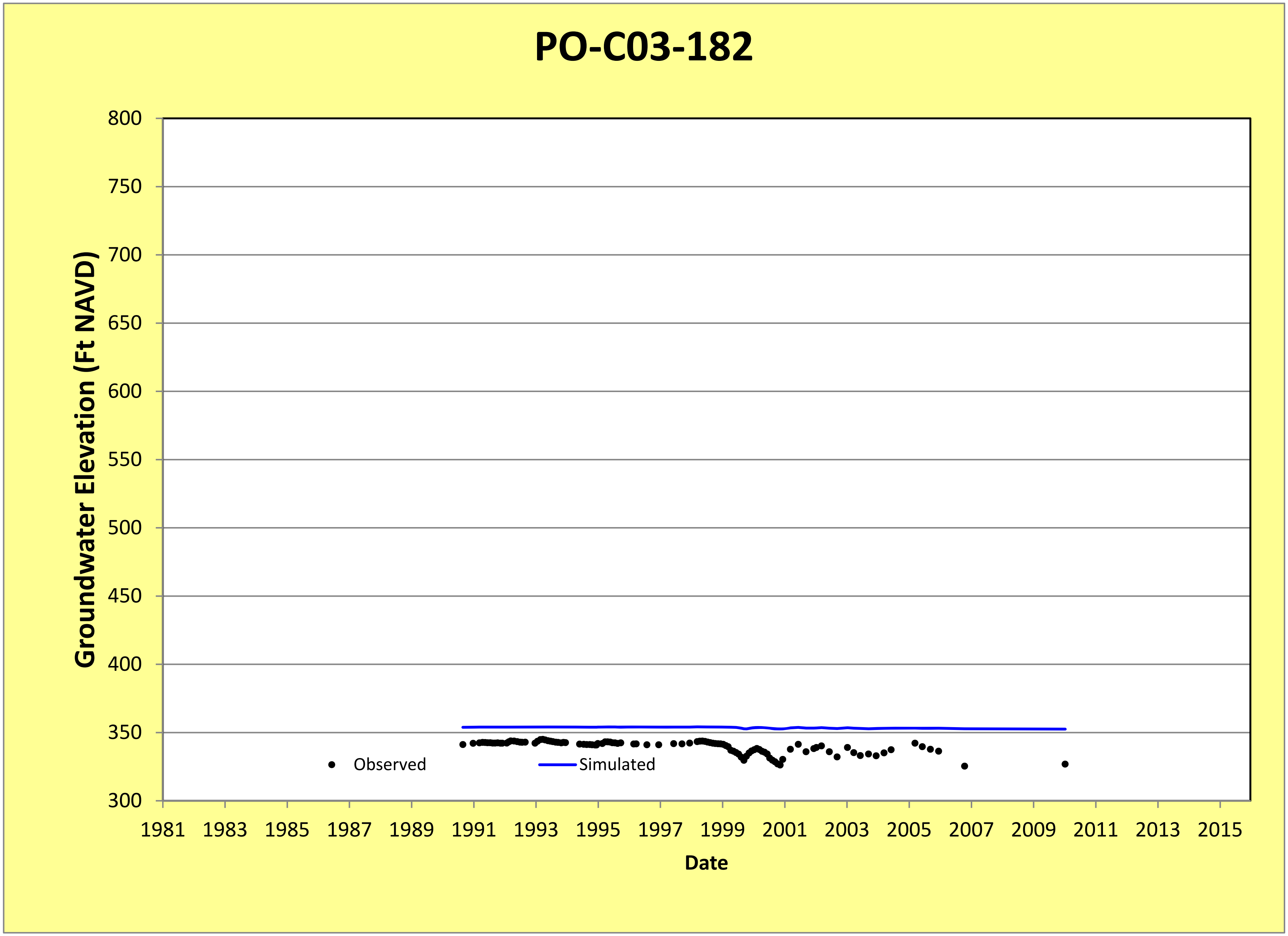
2015
Date



PO-C03-182
Groundwater Elevation (Ft NAVD)
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750
700
650
600
550
500
450
400
350
300
Observed
Simulated
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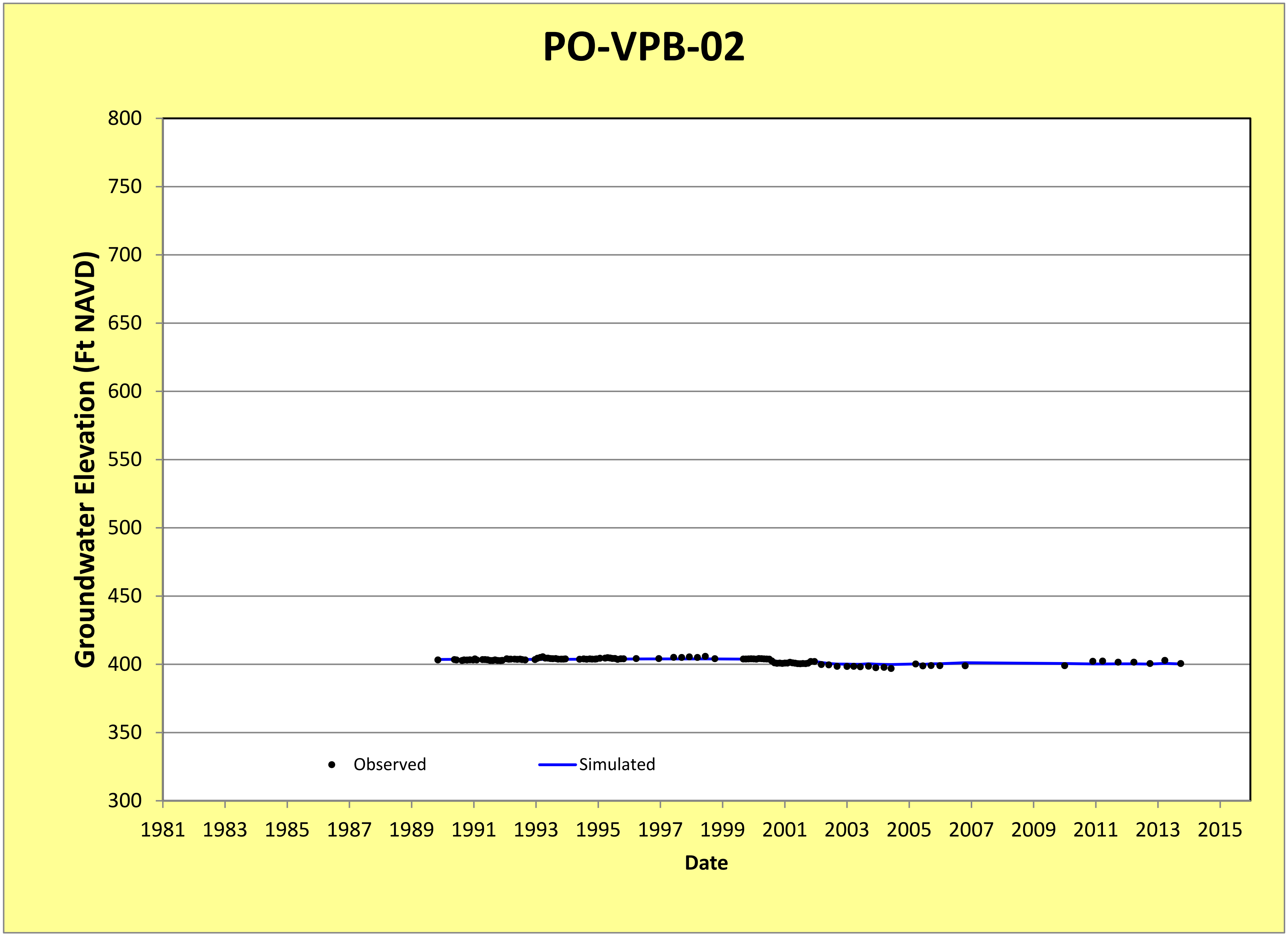
2015
Date


PO-VPB-02
Groundwater Elevation (Ft NAVD)
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750
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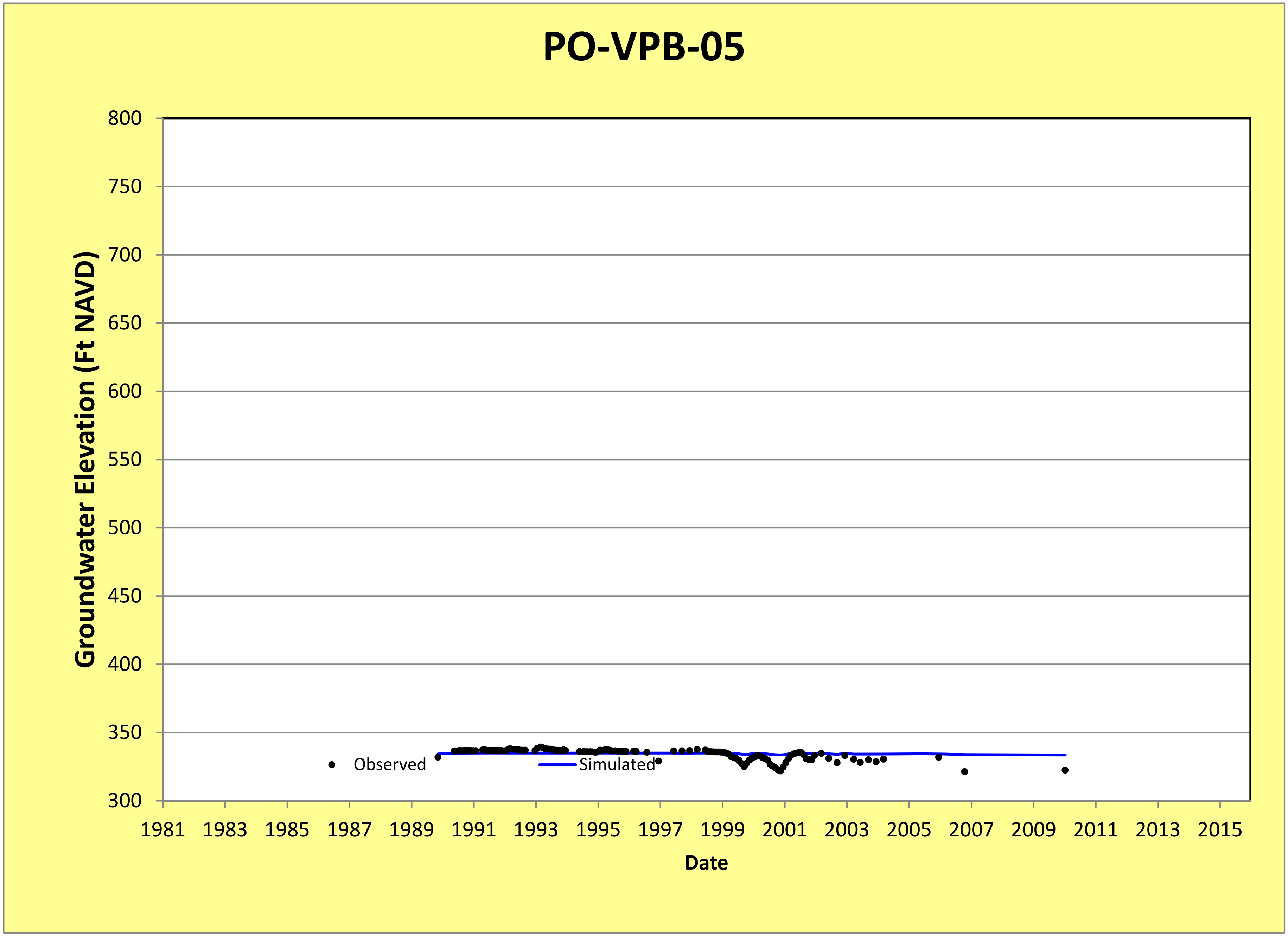
2015
Date
Observed
Simulated


PO-VPB-05
Groundwater Elevation (Ft NAVD)
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750
700
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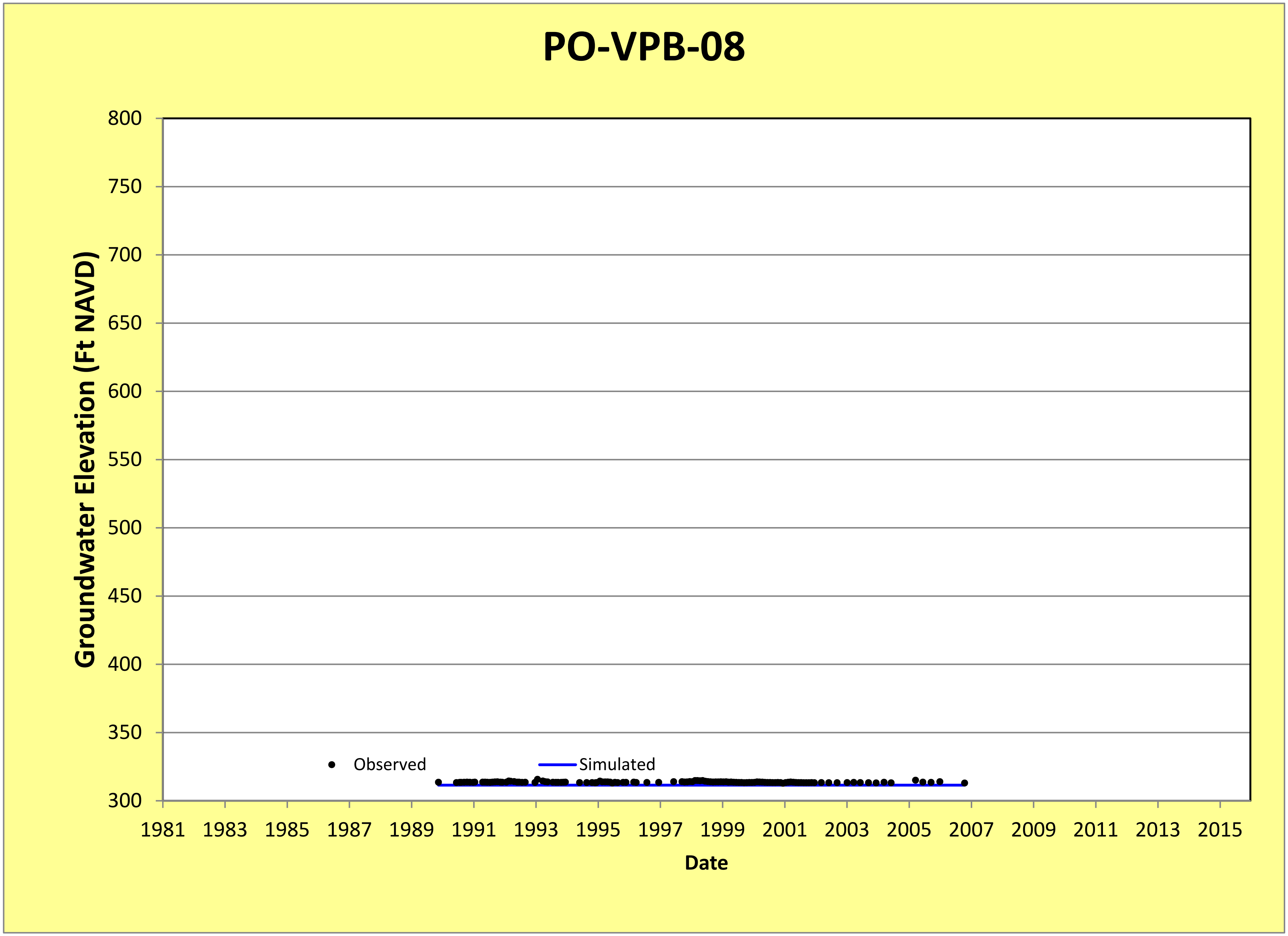
Date
Observed
Simulated


PO-VPB-08
Groundwater Elevation (Ft NAVD)
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750
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550
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Observed
Simulated
1981
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APPENDIX H

Response to USEPA Comments Letter on Draft GMM

APPENDIX H

RESPONSES TO USEPA COMMENTS ON THE DRAFT GROUNDWATER MODELING MEMORANDUM, DATED JUNE 17, 2015

North Hollywood Operable Unit
Second Interim Remedy
Groundwater Remediation Design

This Appendix presents responses to USEPA and stakeholder comments to the Draft Groundwater Modeling Memorandum in a letter dated June 17, 2015 (Attachment 1). As requested, each response (shown with italicized font following each comment or portion of each comment, below) has been incorporated into the Final version of this report.

1. **General Comments:** LADWP requests that the total mass of contaminants removed over the 30 years of operations be estimated for the 4 alternatives, as another way of comparing the options.

   Response: The 2IR Model is not a transport model and cannot be used to directly estimate mass removed. This option was discussed and rejected (for various reasons) during several technical meetings as part of preparing for, and prior to publishing the GMM. Rather, it was agreed that particle tracking (forward and reverse) and probabilistic methods would be sufficient to evaluate the merits of each alternative.

   Concern has been expressed that the dewatering of the A-Zone that is forecast in the future will increase contaminant migration downward into the B-Zone or will strand contamination in the A-Zone, or some combination. The GWMM should provide some analysis of the relative impacts of either of these effects in the years in which the A-Zone is forecasted to be dewatered.

   Response: Methods used in the GMM are consistent with previously employed methods by USEPA and LADWP for determining core plume capture, and add newer methods that support the conclusions made in the GMM. See previous response regarding reliance on mass transport simulations. In addition, the A-Zone is not expected to dewater within the next 20 years during which time significant mass would be extracted from the A-Zone, and results from a mass transport model would not likely result in a significantly different NHOU second interim remedy design.

   Additionally, the simulation forecasts are based on a single set of pumping and recharge assumptions. Given the uncertainty of future precipitation and water supply, it is unlikely that these assumptions will come to pass as forecast. By extension, estimates of potential vertical plume migration as a result of the A-Zone dewatering would also be based on a large degree of uncertainty.

LADWP would like to see a regional map showing observed and simulated groundwater elevation contours for the San Fernando Basin should be provided so that they can assess the reasonableness of the heads and groundwater flow patterns simulated for the NHOU area.

Response: The LADWP has been provided a copy of model input files, which they can use to evaluate model fit, including preparing basin-wide groundwater elevation contour plots. The scope of the GMM was to refine the basin-scale model with additional data specific to the NHOU study area and to further calibrate the model to improve the fit between observed and simulated heads within the NHOU study area. The improved calibration with respect to observed heads in the NHOU study area is sufficient to evaluate their 'reasonableness'.

There are errors in the legend of several figures. Please review and correct.

Response: Figures have been revised accordingly.

2. **Executive Summary**: Page ES-5 notes that in response to projected groundwater withdrawals and recharge by the Los Angeles Department of Water and Power (LADWP), local groundwater flow directions (in the NHOU area) are forecasted to be "dramatically influenced" after year 2024, with a shift in groundwater flow direction from the south-southeast to the west-southwest. Use of a quantitative description rather than "dramatically influenced" is advised to provide more useful information to readers of the GWMM. It should also be noted that shifts in hydraulic gradient of 90 degrees or more likely occurred in the NHOU area on one or more occasions since the 1960s in response to changes in groundwater withdrawal and recharge rates.

   Response: Text has been revised as appropriate.

   In the summary description of the Cooperative Containment Concept, please state, for the purpose of clarity, that LADWP North Hollywood East Branch wells will not be pumped under the CCC pumping plan. North Hollywood East Branch wells are pumped only under the Alternative 4B Scenario.

   Response: Revisions to the text have been made as appropriate.

   In addition, the reference to Figure 1-1 for the location of the current extraction well (on page ES-4, 1st bullet at bottom of page) is incorrect; the proper figure to reference seems to be Figure 3-2.

   Response: Figure 3-2 is the correct figure and text has been revised accordingly.

   Any changes to the main text of the document resulting from the comments below should also be applied to the Executive Summary, as appropriate.

   Response: Revisions to the text and Executive Summary have been made as appropriate.

3. **Section 2.2, "'Simulation F' Model (2012)":** The first sentence of this section states that "…LADWP and USEPA had begun to revise projections of water use in the SFV and to evaluate the potential effect on the proposed NHOU second interim remedy." It should be clarified that LADWP provided forecasts of water use in the SFV in cooperation with the Upper Los Angeles River Area Watermaster, without input from EPA; please revise the sentence accordingly.

   <u>Response</u>: The text has been revised as appropriate.

4. **Section 2.6, "Cooperative Containment Concept":** The LADWP reports that the first paragraph misstates the reason why they proposed the Cooperative Containment Concept. The correct reasons were to:

   a. Improve MCL contaminant plume capture by the NHOU 2IR pumping;

   b. Hasten cleanup of groundwater contamination in the NHOU;

   c. Restore the groundwater resources of the San Fernando Basin to beneficial use; and,

   d. Provide additional drinking water supply to the City of Los Angeles.

   <u>Response</u>: The original text is consistent with discussions with the LADWP, but has been revised as suggested here other than the first point, which will retain focus on the associated RODA objective (i.e., improve the likelihood of meeting the RODA objective to contain areas of contaminated groundwater that exceed the MCLs and notification levels to the extent practicable).

   The last paragraph of this section states "Because the CCC approach results in a treatment capacity that is approximately double that specified in the RODA, the need for optimizing hydraulic capture under the CCC approach is diminished." This sentence be modified to state that greater hydraulic capture will result from the CCC approach, but hydraulic capture should still be optimized to the extent possible.

   <u>Response</u>: Differences between CCC Options 1 and 2 will be minimal with respect to the ROD-objective of capturing the plume core (i.e., 10x MCLs), because both Options achieve that objective, and in fact lesser pumping will achieve that objective. Regardless, revisions to the text have been made as appropriate.

5. **Section 3.1, "Conceptual Site Model Summary":** The introduction to the conceptual site model (CSM) summary section does not list Amec's *"Phase I Pre-Design Investigation Report of Activities from July 2014 To February 2015,"* dated April 24, 2015, as a source of information. If this report, or the data described in it, was a source of information for development of the NHOU CSM, it should be mentioned in Section 3.1.

   <u>Response</u>: This reference has been incorporated into the text as appropriate.

6. **Section 3.1.1, “Hydrostratigraphic Units”:** The third paragraph of this section states that “COC concentrations are much lower in the B-Zone, potentially due to dilution; however, relatively few depth-discrete B-Zone groundwater samples have been collected to date. The A-Zone and B-Zone are key components of the refined CSM because the vertical distribution of COCs strongly correlates with these hydrostratigraphic units.” Please provide supporting information for these statements. Data presented in Table 4 of Amec’s *“Phase I Pre-Design Investigation Report of Activities from July 2014 To February 2015,”* dated April 24, 2015, suggest that TCE concentrations detected in groundwater samples from B-Zone piezometers near extraction wells NHE-2 and NHE-7 are greater than those detected in the adjacent A-Zone piezometers, and the concentrations of TCE detected at the A-Zone and B-Zone piezometers associated with extraction well NHE-4 are approximately equal.

   <u>Response</u>: *Additional explanation has been incorporated into the text; note that additional data is anticipated later this year (as recommended in the draft GMM) that may further clarify this issue.*

   The fourth paragraph of this section notes that many existing monitoring wells in the NHOU area are screened across the A- and B-Zones, and that “Accurately associating groundwater sample depth information with either the A-Zone or B-Zone (or deeper) will be critical to design the 2IR.” Please provide recommendations for achieving accurate association of groundwater sample depth information with the A- and B-Zone (e.g. depth-specific sampling, or replacing existing monitoring wells with new wells with different screened intervals).

   <u>Response</u>: *The modeling conducted has conservatively considered capture of whole aquifer units as reflected in the particle tracking. Further refinement at this time is not expected to alter GMM conclusions, as they are based on defined pumping rates rather than trying to optimize capture flow rates based on vertical distributions within units. The recommended sampling event will include depth-discrete groundwater samples, as were collected in previous events in 2012 and 2013. Future monitoring wells installed in this area should be designed and installed such that screen/filter pack intervals do not bridge the contact between the A-Zone and B-Zone.*

7. **Section 3.1.3, “Contaminant Distribution and Source Areas”:** This section begins with the phrase “Multiple known and potential source areas complicate delineating each COC…” Further discussion of sources is minimal and consists largely of vague generalizations about potential impacts of “multiple sources” on plumes. It is important that the CSM include discussion of the major known and suspected sources of contaminants of concern in the NHOU, and the concentrations remaining in the area of those sources. In the NHOU, high concentrations of TCE (17,000 μg/L), 1,4-dioxane (1,300 μg/L), and hexavalent chromium (440,000 μg/L) were historically detected directly below the former Bendix facility, and high-concentration “hot spots” remain there (although active remediation is ongoing). Based on these historic and current concentrations, the former Bendix facility is certainly one of the

most important source areas in the NHOU and should be specifically discussed in the CSM section of the GWMM. VOC and 1,4-dioxane “hot spots” worth discussing in the GWMM have also been detected below the former Hewitt Pit landfill and west of the Burbank (Bob Hope) Airport.

<u>Response</u>: *The GMM was not intended to provide an extensive discussion of known or potential source areas, which was largely accomplished in the Data Gap Analysis (DGA) report (AMEC, 2012). A thorough discussion of site-specific remediation efforts at known source areas is also beyond the scope of this document and is not necessary to present a reasonably complete CSM. Text has been revised to reference the DGA report in this section.*

8. **Section 3.1.3.2, “A-Zone”:** This section states that “Delineating the lateral and vertical extent of COCs in the A-Zone is difficult because most monitoring wells have been sampled from a single depth…” and “…depth-discrete data are needed to design the new NHOU extraction well field…” Is this language simply an inadvertent cut-and-paste error from a previous document, or does this data gap still exist? Several bullet points in this section go on to state that additional data are needed to delineate TCE, PCE, and 1,4-dioxane concentrations. Is Amec proposing additional well installation and sampling at some point during the remaining RD process?

   <u>Response</u>: *This text, as indicated, is a summary of data presented in the Data Gap Analysis. These gaps have been filled as shown in subsequent sections (e.g., in the updated plume distribution maps resulting from the Phase 1 investigation and in the 95 percent UCL maps). Due to the time passed since the Phase 1 samples were collected, Amec Foster Wheeler is proposing limited additional sampling in the NHOU plume core areas to reduce uncertainties regarding potential COC distribution/shifting in the interim. Revisions to the text have been made as appropriate.*

   The fourth (last) bullet point in Section 3.1.3.2 notes that “…the CDPH promulgated a draft PHG of 0.02 µg/L for hexavalent chromium...” This bullet should reference the new California MCL for hexavalent chromium of 10 µg/L, which became effective on July 1, 2014.

   <u>Response</u>: *Text has been revised accordingly.*

   The fourth bullet point also states that “Additional data from several recently installed monitoring wells suggest that one or more sources other than the former Bendix facility, is responsible for the distribution of hexavalent chromium in A-Zone groundwater.” As written, this sentence seems to imply that the former Bendix facility is ***not*** a source of hexavalent chromium in A-Zone groundwater. Perhaps the words “other than” should be replaced by “in addition to” to clarify this point of the CSM for the reader.

   <u>Response</u>: *Text has been revised accordingly.*

9. **Section 3.2, “Former Bendix Facility Remedial Operations”:** This section describes the ongoing remedial action at the former Bendix facility, and concludes with the statement “When remedial operations are completed, contaminant concentrations, particularly those of hexavalent chromium, in the vicinity of the former Bendix facility are anticipated to be much lower.” However, this section never mentions that concentrations of hexavalent chromium and TCE in groundwater below the former Bendix facility were elevated to begin with. This section should begin with a brief description of conditions at the facility that required remediation.

   Response: As stated in response to Comment #7, text has been revised to include reference to the DGA report to acknowledge additional historical data regarding this site.

10. **Section 3.3, “NHE-2 and NHE-3 Interim Actions”:** Please list the maximum hexavalent chromium concentrations detected at these extraction wells, which resulted in them being shut down.

    Response: Text has been revised to include additional historical data, including maximum historical concentrations, at these wells. Note that pumping at NHE-2 was restored and the well remains active, although extracted water is not delivered to the NHOU treatment system; only well NHE-3 has been and remains shut down.

11. **Section 3.4, “Burbank Operable Unit Remedial Operations”:** This section doesn’t describe much about the Burbank Operable Unit (BOU) remedial operations, other than to simply state that Lockheed-Martin completed source removal and designed/constructed the BOU Water Treatment System. The rest of this discussion focuses on the benefits of conveying water extracted by NHE-7 and NHE-8 to the BOU for treatment. This section would be improved by providing more information about the average extraction/treatment rate occurring in BOU, the treatment method employed, and comparison to anticipated extraction rates and contaminant concentrations at wells NHE-7 and NHE-8 under the Second Interim Remedy.

    Response: Additional text has been provided to further discuss the BOU remedial operations, as suggested.

    Please add a bullet point under the section "The benefits of conveying supply from NHE-7 and NHE-8 ... " to say *"1,4-dioxane levels from NHE-7 and NHE-8 are above the NL for which the BOU does not currently have treatment.”*

    Response: Text has been revised to account for 1,4-dioxane (in addition to VOCs and hexavalent chromium), and that anticipated concentrations are not expected to require modification of the BOU treatment system.

12. **Section 4.7, “Representing Wells in the Model”:** The last paragraph of this section discusses the need for well destruction to eliminate potential vertical conduits. However,

corresponding Table 4-1 does not appear complete. For example, if CCC Option 1 is implemented, then higher priority may be needed for destruction of NH-27 (located near CC-2) and NH-13 and NH-29 (located between CC-3 and CC-4). These wells are not included on Table 4-1.

Response: Table 4-1 has been revised accordingly.

13. **Section 5.3.2, "Horizontal and Vertical Anisotropy":** This section states "A vertical anisotropy of 100 has been assigned in most Kh zones included in the 2IR groundwater flow model…" It would be helpful to describe briefly those portions of the model area where the ratio differs markedly from 1:100.

    Response: Zone 71 had a different ratio (1:50), as was presented to the USEPA and LADWP during the May 18, 2015 technical meeting, and Zone 72 has been revised since to also reflect a 1:50 ratio. As also presented, a sensitivity analysis indicated that the model is not sensitive to the different anisotropy ratio in these zones. The text and associated figure have been revised accordingly.

14. **Section 5.3.3, "Storage Coefficients":** In the discussion of storage properties, specific yield should be used for Layer 1 and specific storage should be used for layer 2 because Layer 1 is an unconfined aquifer at all times, and Layer 2 is a confined aquifer at all simulation times.

    Response: Text has been clarified as necessary. Please note that, in fact, Layer 2 is convertible between confined (S_s) and unconfined (S_y) when and where Layer 1 dewaters.

15. **Section 5.5, "Best-Fit Statistical Measures":** Using the model's overall calibration statistics to evaluate its goodness-of-fit is acceptable when the modeling concern is basin-wide. However, modeling local-scale groundwater flow patterns requires scrutiny of the model's goodness-of-fit at a corresponding scale. The 2IR model is mainly focused on the region between the North Hollywood West and Rinaldi-Toluca Well Fields, and south to the Burbank extraction well field. It is therefore important to understand how well the model fits the calibration in this vicinity, and whether there are hydraulic gradient differences or other discrepancies between simulation and measured values. It is therefore recommended that separate calibration scatter grams like those presented in Figure 5-5 be included for the smaller 2IR area of interest, and that any noticeable trends in calibration error at that scale are discussed in the GWMM. Plan view maps showing contours of average well residuals would also be helpful. It is recognized that calibration statistics like RMS/range are likely to increase as the range of heads falls from several hundred to a few dozen feet.

    Response: The last column of Table 5-1 shows the summary statistics for the NHOU study area only. Note that a correlative graphic was presented to the USEPA and the LADWP on May 18, 2015 in a technical stakeholder meeting, and has now been incorporated into the final GMM as Figure 5-5b.

16. **Section 6.2.1, “Forecast Alternative 4B (Scenario 1)”:** What is the ultimate disposition of the water produced by NHE-7 and NHE-8 and sent to the BOU for treatment: was it assumed to be reinjected along with other Alternative 4B treated water, or some other end use?

    Response: As stated, water extracted from wells NHE-7, NHE-8, and New-4 under Alternative 4B would be sent to the BOU to be treated and discharged to the City of Burbank for potable use, rather than to be reinjected with other Alternative 4B treated water (i.e., from extraction wells NHE-1 through NHE-6).

    The North Hollywood East branch wells that are pumping are identified, and the wells scheduled for destruction listed are in Table 4-1, "Proposed Production Well Destruction Priority." However, it is not clear if the non-pumping North Hollywood East branch wells not listed in Table 4-1 are simulated as vertical conduits in the model or treated as having been destroyed. In addition, the wells listed in Table 4-1 are different than the wells listed in the text in section 6.2 and 6.3 as being destroyed. Please revise.

    LADWP reports that if they are to be responsible for the destruction of the wells listed in Table 4-1, the schedule could take longer than the 2-3 year period presented.

    Response: Table 4-1 and the text will be made consistent with the text and the NH East Branch wells will be specifically addressed. Our recommended timeline was intended to present a schedule of destroying vertical conduits as soon as practicable to minimize vertical cross-flow.

17. **Section 7.0 “Forecast Simulation Results”:** It is unclear from the plume capture efficiency discussions what percentage (if any) of particles escape capture by wells and are captured by other receptors such as the Los Angeles River. Please clarify.

    Response: Table 7-1 accounted for 10 x MCL core plume (i.e. the central and eastern plumes) particles captured by “other” receptors without specifying what these receptors were (e.g., a specific well field or particles still in transit). This table has been reformatted for each scenario to indicate the percent capture of the central and eastern core plumes by specific well field, and particles still in transit. None of the simulated particles migrate to the LA River. Color codes have been added to the plume particle maps to indicate the ultimate fate of the particles, in addition to the zone they are traveling through. It is important to remember that capture of a particle from the COC plume core by a nearby municipal well does not necessarily mean that the well will be adversely impacted. The particle tracking shows that the particle pathway to most municipal wells is often long and convoluted, as such, the concentration of COCs represented by the particle will likely be highly diluted by the time it reaches the well.

18. **Section 7.6, “Comparison of Scenarios”:** The text below the table at the top of page 71 states that “A-Zone plume capture efficiencies reflect essentially 100% percent capture of

the central plume area and capture of approximately the northern half of the eastern plume area for Alternative 4B; capture efficiencies are nearly 100% of both areas (cumulatively) for all remedies." However, the capture efficiency values provided in the table at the top of page 71 seem to indicate that the Alternative 4B options would provide only 53 to 72 percent capture efficiency of the plume core in the A-Zone. Please explain how that reflects "essentially 100% capture."

Response: The statement should have read "A-Zone plume capture efficiencies reflect the combined capture efficiency for the central plume and eastern plumes. For Alternative 4B, approximately 100% of the central plume area is captured by the NHOU extraction wells and approximately 50% to 60% (the northern half) of the eastern plume area is captured by the NHOU extraction wells, the remaining percentage of the eastern plume is captured by BOU extraction wells. For the CCC Approach, approximately 100% of the central plume area is captured by the NHOU extraction wells and approximately 90% to 100% of the eastern plume area is captured by the NHOU extraction wells, a small percentage is captured by other well fields. Note that capture efficiencies tend to drop in the later years of the simulation as a result of several factors including: changing groundwater flow directions, partial dewatering of the A-Zone, competition from other wells fields, and insufficient travel time (particles are still in transit)." As noted above Table 7-1 has been reformatted to clarify the percent capture of the central and eastern core plumes by specific well field. This statement will be corrected as indicated.

Section 7.6 (page 72, first bullet point) states "Alternative 4B and the CCC approach are both viable remedies that would meet RAOs stipulated in the RODA." If Alternative 4B, Scenario 2, allows 100% of B-Zone contamination in the plume core to escape capture, as the tables appear to suggest, then it is not reasonable to suggest that this remedy would meet the 2014 Record of Decision Amendment objective to "Prevent further degradation of water quality at Rinaldi Toluca and NH-WB" Please provide more explanation of this conclusion.

Response: Alternatives 4B Scenarios 1 and 2 both meet RAOs related to capture of the A-Zone plume core as indicated in the FFS and the results of this GMM. Alternative 4B, Scenario 2 was provided as a sensitivity simulation of Alternative 4B, Scenario 1, to demonstrate a large percentage of the COC plume (mostly B-zone) is captured by NH East wells.

Alternative 4B, Scenario 1 includes proposed pumping from the 8 existing NHOU wells, 4 New wells, and several NH-East Branch production wells. As shown on updated Table 7-1a, this scenario shows between 49% and 100% plume core capture in the A-Zone and between 50% and 95% plume core capture in the B-Zone, depending on time. Alternative 4B, Scenario 2 was provided to evaluate how pumping from the NH-East Branch production wells affected containment and capture of B-Zone COC's. This was done by turning off the

NH East wells (reducing pumping by about 10,500 AFY); however, no attempt was made to re-allocate the lost production. Without the NH-East Branch production wells pumping, implementing the Alternative 4B, Scenario 2 (Table 7-1b) would result in between 56% and 100% plume core capture in the A-Zone and between 1% and 65% plume core capture in the B-Zone (assuming the lost production was not restored by another production well field). However, aside from uncertainty stemming from lost production, it cannot be concluded that simulated particle pathlines intercepting production wells (e.g., NH-West Branch), as indicated by Alternative 4B, Scenario 2, necessarily means that groundwater quality would measurably degrade or that additional treatment would be required. Regardless, COCs in the 'central plume area' of the B-Zone appear to be an extension of a COCs plume that originates in the 'western plume area'; this area was not included in the RODA and thus results from Alternative 4B, Scenario 2 are not inconsistent with meeting RODA objectives.

In addition, during the Stakeholder meetings, we reiterated an interest in seeing the capture efficiencies to the MCL "envelope" for each pumping scenario, in addition to the "plume core" capture efficiencies. Please include these efficiency statistics in the final memo.

<u>Response</u>*: Calculating the plume capture efficiency with respect to the MCL footprint does not change the alternative selection process because (1) the objective of the NHOU second interim remedy is to target removal of the plume core (i.e., 10 x MCLs), and capture efficiencies as presented provide a sufficient means for comparing remediation alternatives, and (2) plume efficiencies presented in the GMM are already conservative because the plume footprint is assumed to remain constant over time. As such, additional plume capture efficiency values based on MCLs have not been provided in the Final GMM.*

19. **Table 6-1:** It would be helpful to include well coordinates and screen interval depths or elevations.

    <u>Response</u>*: Well coordinates and screen elevations have been added to Table 6-1.*

20. **Figure 5-6:** What components of recharge were used to test model sensitivity during the sensitivity analysis? Providing this information allows LADWP to assess the resilience of model calibration under variations in precipitation or due to climate change.

    <u>Response</u>*: Only the regional annual recharge rates were modified for this sensitivity analysis. The text and Figure 5-6 have been clarified accordingly.*

    What is the explanation for the large increases in the residual of sum squares when recharge is increased by a factor of two or more? Given that areal recharge can be highly variable (as a function of precipitation), does this mean that model calibration (and model predictions) will be poor for wet years?

    <u>Response</u>*: The residual sum of squares (RSS) increase is less than a factor of 10, which was accentuated by the chart scale. Annual recharge is based on estimated native runoff*

and areal precipitation of about 43,660 AFY. Due to the relatively thick vadose zone, temporal variation in recharge are "smoothed" out and the water table responds to the average annual rate of recharge (as was also concluded by CH2M Hill in their 2013 Model Update report). Doubling the annual average rate of recharge would be expected to have a significant impact on the model water balance as demonstrated by the RSS.

21. **Figure 6-2:** It appears that the areal recharge rate assigned to spreading grounds is lower than the recharge rate applied to other areas of the basin. Even when not used for spreading, the areal recharge rate of spreading groundwater should be higher than surrounding areas due to the high permeability of materials in these spreading grounds.

    Response: The recharge rates applied to the spreading grounds is always equal to or greater than the regional areal recharge rate for that location. The areal recharge rate of the spreading grounds should not exceed that of the surrounding area because the same amount of precipitation falls on the spreading grounds as on the surrounding area. If storm water runoff is routed to the spreading grounds, then additional recharge should be accounted for in the model.

22. **Figures 7-4a, and 7-8a, b "(Forward particle tracking, Alternative 4B)":** It would be helpful to have the particle traces color coded by receptor rather than layer. It is difficult to tell which particles escape capture by NHOU or BOU pumping in the current presentation.

    Response: As with our response to Comment #17, particle tracks have been revised to reflect the receptor (e.g., well field) in addition to the layer that the particle travels through. Figures have also been revised to a larger format to improve their legibility.

23. **Appendices D through G:** The title pages of Appendices D through G are not consistent with their contents or, in some cases, the titles given in the table of contents for the Draft GWMM. Please correct in the final version of the GWMM.

    Response: Title pages have been revised accordingly.

ATTACHMENT 1

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 9
75 Hawthorne Street
San Francisco, California

June 17, 2015

Michael Taraszki
AMEC for Honeywell and Lockheed
1330 Broadway Street, Suite 1702
Oakland, CA 94612

RE: Comments on *Draft Groundwater Modeling Memorandum, North Hollywood Operable Unit Second Interim Remedy, Groundwater Remediation Design*, dated April 2015

Dear Mr. Taraszki:

EPA has reviewed the subject document, and provides the comments attached to this letter. Please incorporate the responses into the final report, and provide a response to comment summary memo when submitting the final to EPA.

The Final Groundwater Modeling Memo and response to comments are due July 21, 2016.

Please feel free to contact me at 415-972-3290 if you have any questions on these comments.

Sincerely,

Kelly S Man

Kelly Manheimer
EPA Superfund Project Manager

Attachment

1. **General Comments:** LADWP requests that the total mass of contaminants removed over the 30 years of operations be estimated for the 4 alternatives, as another way of comparing the options.

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    b. Hasten cleanup of groundwater contamination in the NHOU;
    c. Restore the groundwater resources of the San Fernando Basin to beneficial use; and,
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    The last paragraph of this section states "Because the CCC approach results in a treatment capacity that is approximately double that specified in the RODA, the need for optimizing hydraulic capture under the CCC approach is diminished." This sentence be modified to state that greater hydraulic capture will result from the CCC approach, but hydraulic capture should still be optimized to the extent possible.

5. **Section 3.1, "Conceptual Site Model Summary:"** The introduction to the conceptual site model (CSM) summary section does not list Amec's *"Phase I Pre-Design Investigation Report of Activities from July 2014 To February 2015,"* dated April 24, 2015, as a source of information. If this report, or the data described in it, was a source of information for development of the NHOU CSM, it should be mentioned in Section 3.1.

6. **Section 3.1.1, "Hydrostratigraphic Units:"** The third paragraph of this section states that "COC concentrations are much lower in the B-Zone, potentially due to dilution; however, relatively few depth-discrete B-Zone groundwater samples have been collected to date. The A-Zone and B-Zone are key components of the refined CSM because the vertical distribution of COCs strongly correlates with these hydrostratigraphic units." Please provide supporting information for these statements. Data presented in Table 4 of Amec's *"Phase I Pre-Design Investigation Report of Activities from July 2014 To February 2015,"* dated April 24, 2015, suggest that TCE concentrations detected in groundwater samples from B-Zone piezometers near extraction wells NHE-2 and NHE-7 are greater than those detected in the adjacent A-Zone piezometers, and the concentrations of TCE detected at the A-Zone and B-Zone piezometers associated with extraction well NHE-4 are approximately equal.

    The fourth paragraph of this section notes that many existing monitoring wells in the NHOU area are screened across the A- and B-Zones, and that "Accurately associating groundwater sample depth information with either the A-Zone or B-Zone (or deeper) will be critical to design the 2IR." Please provide recommendations for achieving accurate association of groundwater sample depth information with the A- and B-Zone (e.g. depth-specific sampling, or replacing existing monitoring wells with new wells with different screened intervals).

7. **Section 3.1.3, "Contaminant Distribution and Source Areas:"** This section begins with the phrase "Multiple known and potential source areas complicate delineating each COC…" Further discussion of sources is minimal and consists largely of vague generalizations about potential impacts of "multiple sources" on plumes. It is important that the CSM include discussion of the major known and suspected sources of contaminants of concern in the NHOU, and the concentrations remaining in the area of those sources. In the NHOU, high concentrations of TCE (17,000 µg/L), 1,4-dioxane (1,300 µg/L), and hexavalent chromium (440,000 µg/L) were historically detected directly below the former Bendix facility, and high-concentration "hot spots" remain there (although active remediation is ongoing). Based on these historic and current concentrations, the former Bendix facility is certainly one of the most important source areas in the NHOU and should be specifically discussed in the CSM section of the GWMM. VOC and 1,4-dioxane "hot spots" worth discussing in the GWMM have also been detected below the former Hewitt Pit landfill and west of the Burbank (Bob Hope) Airport.

8. **Section 3.1.3.2, "A-Zone:"** This section states that "Delineating the lateral and vertical extent of COCs in the A-Zone is difficult because most monitoring wells have been sampled from a single depth…" and "…depth-discrete data are needed to design the new NHOU extraction well field…" Is this language simply an inadvertent cut-and-paste error from a previous document, or does this data gap still exist? Several bullet points in this section go on to state that additional data are needed to delineate TCE, PCE, and 1,4-dioxane concentrations. Is Amec proposing additional well installation and sampling at some point during the remaining RD process?

   The fourth (last) bullet point in Section 3.1.3.2 notes that "…the CDPH promulgated a draft PHG of 0.02 µg/L for hexavalent chromium..." This bullet should reference the new California MCL for hexavalent chromium of 10 µg/L, which became effective on July 1, 2014.

   The fourth bullet point also states that "Additional data from several recently installed monitoring wells suggest that one or more sources other than the former Bendix facility, is responsible for the distribution of hexavalent chromium in A-Zone groundwater." As written, this sentence seems to imply that the former Bendix facility is ***not*** a source of hexavalent chromium in A-Zone groundwater. Perhaps the words "other than" should be replaced by "in addition to" to clarify this point of the CSM for the reader.

9. **Section 3.2, "Former Bendix Facility Remedial Operations:"** This section describes the ongoing remedial action at the former Bendix facility, and concludes with the statement "When remedial operations are completed, contaminant concentrations, particularly those of hexavalent chromium, in the vicinity of the former Bendix facility are anticipated to be much lower." However, this section never mentions that concentrations of hexavalent chromium and TCE in groundwater below the former Bendix facility were elevated to begin with. This section should begin with a brief description of conditions at the facility that required remediation.

10. **Section 3.3, "NHE-2 and NHE-3 Interim Actions:"** Please list the maximum hexavalent chromium concentrations detected at these extraction wells, which resulted in them being shut down.

11. **Section 3.4, "Burbank Operable Unit Remedial Operations:"** This section doesn't describe much about the Burbank Operable Unit (BOU) remedial operations, other than to simply state that Lockheed-Martin completed source removal and designed/constructed the BOU Water Treatment System. The rest of this discussion focuses on the benefits of conveying water extracted by NHE-7 and NHE-8 to the BOU for treatment. This section would be improved by providing more information about the average extraction/treatment rate occurring in BOU, the treatment method employed, and comparison to anticipated extraction rates and contaminant concentrations at wells NHE-7 and NHE-8 under the Second Interim Remedy.

    Please add a bullet point under the section "The benefits of conveying supply from NHE-7 and NHE-8 ... " to say *"1,4-dioxane levels from NHE-7 and NHE-8 are above the NL for which the BOU does not currently have treatment."*

12. **Section 4.7, "Representing Wells in the Model:"** The last paragraph of this section discusses the need for well destruction to eliminate potential vertical conduits. However, corresponding Table 4-1 does not appear complete. For example, if CCC Option 1 is implemented, then higher priority may be needed for destruction of NH-27 (located near CC-2) and NH-13 and NH-29 (located between CC-3 and CC-4). These wells are not included on Table 4-1.

13. **Section 5.3.2, "Horizontal and Vertical Anisotropy:"** This section states "A vertical anisotropy of 100 has been assigned in most Kh zones included in the 2IR groundwater flow model…" It would be helpful to describe briefly those portions of the model area where the ratio differs markedly from 1:100.

14. **Section 5.3.3, "Storage Coefficients:"** In the discussion of storage properties, specific yield should be used for Layer 1 and specific storage should be used for layer 2 because Layer 1 is an unconfined aquifer at all times, and Layer 2 is a confined aquifer at all simulation times.

15. **Section 5.5, "Best-Fit Statistical Measures:"** Using the model's overall calibration statistics to evaluate its goodness-of-fit is acceptable when the modeling concern is basin-wide. However, modeling local-scale groundwater flow patterns requires scrutiny of the model's goodness-of-fit at a corresponding scale. The 2IR model is mainly focused on the region between the North Hollywood West and Rinaldi-Toluca Well Fields, and south to the Burbank extraction well field. It is therefore important to understand how well the model fits the calibration in this vicinity, and whether there are hydraulic gradient differences or other discrepancies between simulation and measured values. It is therefore recommended that separate calibration scatter grams like those presented in Figure 5-5 be included for the smaller 2IR area of interest, and that any noticeable trends in calibration error at that scale are discussed in the GWMM. Plan view maps showing contours of average well residuals would also be helpful. It is recognized that calibration statistics like RMS/range are likely to increase as the range of heads falls from several hundred to a few dozen feet.

16. **Section 6.2.1, "Forecast Alternative 4B (Scenario 1):"** What is the ultimate disposition of the water produced by NHE-7 and NHE-8 and sent to the BOU for treatment: was it assumed to be reinjected along with other Alternative 4B treated water, or some other end use?

    The North Hollywood East branch wells that are pumping are identified, and the wells scheduled for destruction listed are in Table 4-1, "Proposed Production Well Destruction Priority." However, it is not clear if the non-pumping North Hollywood East branch wells not listed in Table 4-1 are simulated as vertical conduits in the model or treated as having been destroyed. In addition, the wells listed in Table 4-1 are different than the wells listed in the text in section 6.2 and 6.3 as being destroyed. Please revise.

    LADWP reports that if they are to be responsible for the destruction of the wells listed in Table 4-1, the schedule could take longer than the 2-3 year period presented.

17. **Section 7.0 "Forecast Simulation Results:"** It is unclear from the plume capture efficiency discussions what percentage (if any) of particles escape capture by wells and are captured by other receptors such as the Los Angeles River. Please clarify.

18. **Section 7.6, "Comparison of Scenarios:"** The text below the table at the top of page 71 states that "A-Zone plume capture efficiencies reflect essentially 100% percent capture of the central plume area and capture of approximately the northern half of the eastern plume area for Alternative 4B; capture efficiencies are nearly 100% of both areas (cumulatively) for all remedies." However, the capture efficiency values provided in the table at the top of page 71 seem to indicate that the Alternative 4B options would provide only 53 to 72 percent capture efficiency of the plume core in the A-Zone. Please explain how that reflects "essentially 100% capture."

    Section 7.6 (page 72, first bullet point) states "Alternative 4B and the CCC approach are both viable remedies that would meet RAOs stipulated in the RODA." If Alternative 4B, Scenario 2, allows 100% of B-Zone contamination in the plume core to escape capture, as the tables appear to suggest, then it is not reasonable to suggest that this remedy would meet the 2014 Record of Decision Amendment objective to "Prevent further degradation of water quality at Rinaldi Toluca and NH-WB" Please provide more explanation of this conclusion.

    In addition, during the Stakeholder meetings, we reiterated an interest in seeing the capture efficiencies to the MCL "envelope" for each pumping scenario, in addition to the "plume core" capture efficiencies. Please include these efficiency statistics in the final memo.

19. **Table 6-1:** It would be helpful to include well coordinates and screen interval depths or elevations.

20. **Figure 5-6:** What components of recharge were used to test model sensitivity during the sensitivity analysis? Providing this information allows LADWP to assess the resilience of model calibration under variations in precipitation or due to climate change.

    What is the explanation for the large increases in the residual of sum squares when recharge is increased by a factor of two or more? Given that areal recharge can be highly variable (as a function of precipitation), does this mean that model calibration (and model predictions) will be poor for wet years?

21. **Figure 6-2:** It appears that the areal recharge rate assigned to spreading grounds is lower than the recharge rate applied to other areas of the basin. Even when not used for spreading, the areal recharge rate of spreading groundwater should be higher than surrounding areas due to the high permeability of materials in these spreading grounds.

    It also appears that the areal recharge rate assigned to spreading grounds is lower than the recharge rate applied to other areas of the basin. Even when not used for spreading, the areal recharge rate of spreading groundwater should be higher than surrounding areas due to the high permeability of materials in these spreading grounds.

22. **Figures 7-4a, and 7-8a, b "(Forward particle tracking, Alternative 4B):"** It would be helpful to have the particle traces color coded by receptor rather than layer. It is difficult to tell which particles escape capture by NHOU or BOU pumping in the current presentation.

23. **Appendices D through G:** The title pages of Appendices D through G are not consistent with their contents or, in some cases, the titles given in the table of contents for the Draft GWMM. Please correct in the final version of the GWMM.